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COMPETITION SCIENCE VISION

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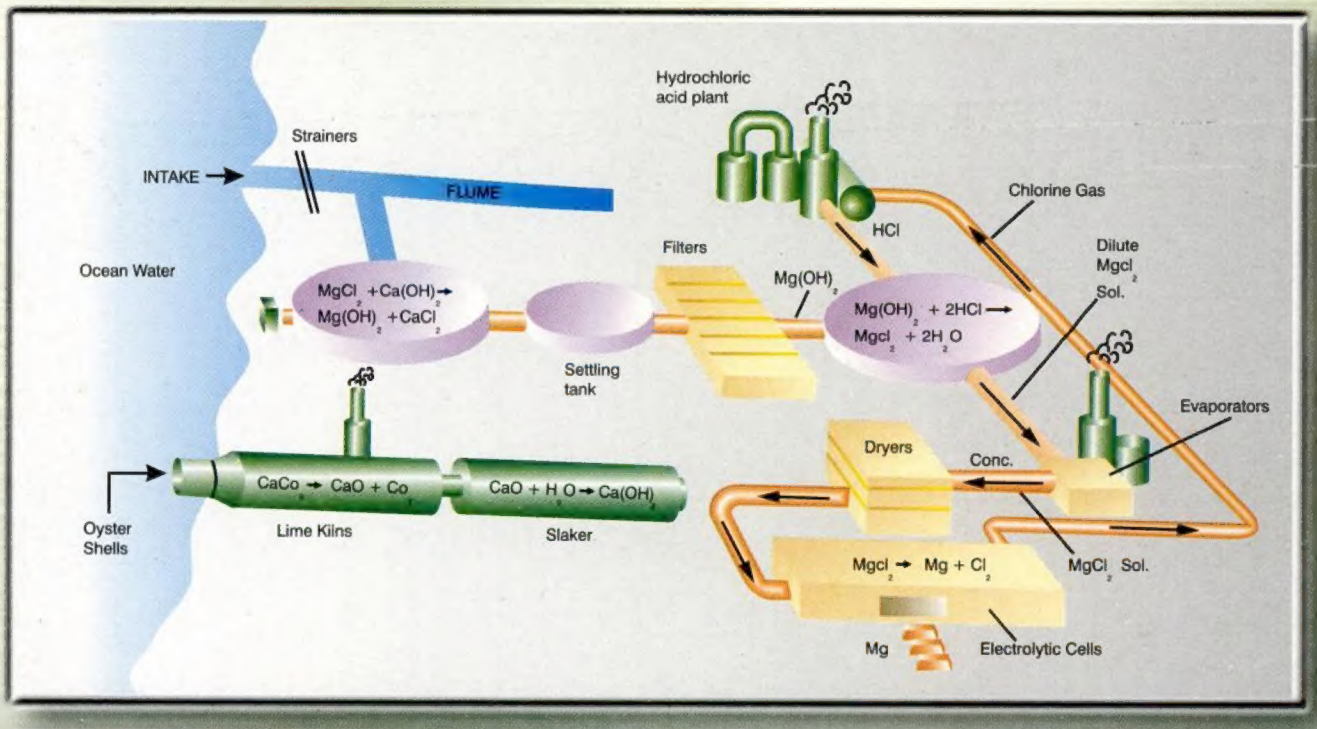

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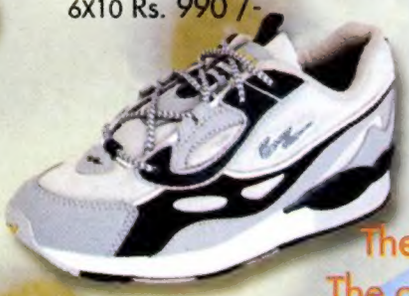

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COMPETITION SCIENCE VISION

March 2000

Year–3 Issue–25

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In This Issue

Physics

Chemistry

Zoology

Botany

Other Features

COMPETITION SCIENCE VISION

To Our Readers

Dear Readers,

We feel delighted in presenting to you the March issue of your favourite magazine 'Competition Science Vision'. As pre-medical examinations are drawing nearer, we are making our issues totally examination oriented. From this point of view important and error free reading material given in this issue is superb and matchless. To enable you to clearly understand the basic ideas underlying the problems, answers have been supplemented with necessary hints and to-the-point explanations.

As you are aware, preparing for a competitive examination is an ardous task and the competition for entry into a medical institute/college of repute is still more ardous. In such a situation the benefits you can derive from reading CSV are enormous. Through it you can receive expert, proven and scientific guidance for every important medical admission test in the country. You will receive the benefits of the collective efforts of team of experts and experienced persons. Rely on us as we rely on their expertise and experience to keep you abreast.

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Wishing you all success in every walk of life.

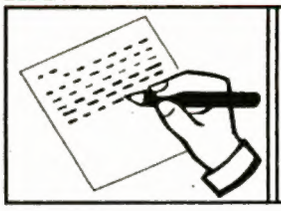
Mahendra Jain
(Editor)

FORTHCOMING COMPETITIVE EXAMS.

2000

'NIFT' in Diploma and P.G. Diploma Exam.	(Feb. 12, 13)	I.I.T. Main Exam.	(May 7)
S.B.I. P.O. Exam.	(Feb. 13)	AFMC M.B.B.S. Entrance Test	(May 7)
Navodaya Vidyalaya Joint Entrance Test	(Feb. 13)	National Defence Academy Exam.	(May 7)
Association of Indian Management Schools (AIMS) Test for ATMA	(Feb. 20)	Roorkee Engineering (Main) Exam.	(May 11 & 12)
B.S.R.B. Bangalore (Canara, Corporation & Vijaya Bank) P.O. Exam.	(Feb. 20)	C.B.S.E. Medical Entrance Test	(May 14)
S.S.C. Combined Preliminary (Graduate Level) Exam.	(Feb. 27)	B.S.R.B. (Calcutta) Clerical Exam.	(May 14)
Madhya Pradesh B.Ed. Entrance Test, 2000	(March 12)	S.S.C. Combined Preliminary (Metric Level) Exam.	(May 21)
Combined Defence Service Exam.	(April 9)	U.P. Combined State/Subordinate Services (P) Exam. 2000	(May 28)
Joint Entrance Test in Hotel Management (3 years Diploma Course)	(April 16)	U.P. Polytechnic Entrance Test (For 2000-2001)	(May 28, 30)
M.P. P.S.C. Exam. 2000	(April 30)	Civil Service (Preliminary) Exam. 2000	(June 4)
		B.H.U. Medical Entrance Test	(June 4)
		B.S.R.B. (Chennai) P.O. Exam.	(Oct. 30)

Editorial



God will help you if you help yourself

We all agree that the picture of India is dim and its future is bleak. There is poverty in plenty. The danger of India's future lies in the lack of public spirit, lies in the lack of true and enlightened patriotism, and so on. But the question is why ? The answer is—we have forsaken the rules of life—to think for ourselves and depend upon our ownselves. This is because we have accustomed ourselves to foreign help specially the American dollars and the sacks of American wheat which the people sitting in the White House do not think fit for human consumption—the people of America. If people of India have lost sight of their capabilities, and forgotten the lessons in self help, it is quite natural, because no link can stand without its bottom. Out of human compassion help of the World Bank and Save the free world and of America have made the Indian leaders lose trust in themselves, and this distrust is the cause of all failures and miseries. Boult has rightly said that "They are the weakest, however strong, who have no faith in themselves or their powers."

Most of the people believe that they believe in God, and say that if not someone else, we must depend on God for help and success. But have they cared or tried to know, what God has to tell them. A poet heard His voice and he wrote.

I asked God to grant me
patience, God said 'No',
Patience is a byproduct of
tribulations; it isn't granted,
it is learned.

I asked God to give me
happiness, God said 'No' I
give you blessings, happiness
is up to you.

I asked God to spare me
pain, God said 'No', Suffering
draws you apart from worldly
cares and brings you
closer to Me.

I asked God for all things that
I might enjoy life. God said 'No',
I will give you life so that
you may enjoy all things

I asked God to help me love
others, as much as He loves me
God said... Ah, finally you
have the idea !

So, we must realise the message of truth in the old proverb—Rely only on yourself. God helps those who help themselves. When God has bestowed all blessings on ourselves, then why do we not move our limbs the blessed ones. It is our everyday experience that no one can climb the mountain peaks or the stairs of success with his hands in his pocket.

If we depend on some body for help, it means we should act according to his biddings or make ourselves his slaves, meaning thereby losing our freedom to act as per our free will, which our soul has achieved after so many incarnations.

Self-help is the capacity to stand on one's legs, without anybody's help. It means the capacity to be at peace with oneself, to preserve one's self-respect, when outside help is not coming or it is refused.

The man, with confidence in himself, howsoever small in the eyes of the worldly people, is always bubbling with enthusiasm to comeforward and face the dark forces. The world-poet Rabindranath Tagore, in his poetic style goads us to take inspiration from the little earthen lamp—

Who will take my work
Asks the setting sun
None has an answer in the
whole silent world
The earthen lamp says, humbly
from a corner.
"I will, my lord, as best as I can."

So, young men and women, remember that self-reliance is the basis of all great and chivalrous acts (Emerson). The man was right, who, with a squint in his eye, said, that-"with a little luck and plenty of pluck, a bad mouse sold may bring in gold."

It has become customary to say that to be successful at the examinations, one must adopt underhand methods and seek recommendations. But people do not try to know the percentage of candidates who have succeeded through the back door entry. Let you be sure, our young friends, that the road to success is not so simple, as some people try to make it out. It is hedged with thorns. One, who is eager to reach the top, has to clean the thorny and rough road, and that too, with his own hands. Plato, the Greek philosopher and father of the western philosophy made it clear in one of his dialogues that, "the man who makes everything that leads to happiness depends upon himself, and not upon other men, has adopted the very best plan for living happily. This is the man of character and wisdom."

After the proverbial massacre, Nadirshah rode on an elephant to go round the streets of Delhi to see how much blood he had shed. He asked the elephant driver to hand over to him the driving instrument. But the elephant man pleaded inability saying that it was he alone who could manage the elephant. At once Nadirshah jumped from the elephant's back, saying "I do not want that my movements be in the hands of someone else." We may abhor Nadirshah for all that he did, but he did set an unique example in self-reliance.

A man who is pledged to self-reliance must be a man with self-confidence, and a man of self-confidence must complete whatever he takes into his hand.

Our young friends will do well to remember these words of the great philosopher mathematician Phythagorus that—"Above all things, reverence yourself."

THOUGHTS FOR THE MONTH

- You can not step into same water in a river twice.
- There is not much time to lose. Soon it might be too late.
- All glory comes from those who dare.
- Facts do not change with the passage of time.
- All happy families seem alike but every unhappy family is sad in its own way.
- To err is human, to admit one's fault is super-human.
- A vocal minority can create the impression of being the majority.
- Those who have sharp tongue must not have sensitive skin.
- Boots may be different but lickers are the same.
- Fortune favours the brave and success sides the valient.
- Liquor on culmination utters the truth.
- Money earned without sweat creates its own problem.
- Be neither saint, nor sophist-led, but a man.
- Money is what money does.
- A highbrow is a person educated beyond his intelligence.
- In absence of necessary evidence it would be wiser to suspend judgement than to jump to conclusions.
- Appeasement never pays; it only whets the appetite of the appeased.
- Faith never fails. Have faith and never give up.

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SCIENCE NEWS

New Hepatitis-B Vaccine

Hyderabad-based Biological E. Limited announced the launch of **Bevac**, a new generation recombinant Hepatitis-B vaccine. Marketed under the brand name BEVAC, the vaccine, unlike the other conventional brands in the market which use the toxic caesium chloride in the purification process, Bevac uses caesium-free technology making it safe for use.

Bevac is the product of an award winning technology in R & D excellence developed by Hyderabad-based Bharat Biotech International Limited. It was noted that Hepatitis-B is a dreaded disease which destroys liver and could lead to death due to liver cirrhosis or cancer. India has the largest pool of Hepatitis-B carriers. The company is planning to include the vaccine in the government's immunisation programme. The company is also working on a project to develop an Indian version of the vaccine for dengue.

First medical cyclotron in South Asia to function by 2001

South Asia's first medical cyclotron being developed by the Calcutta-based Saha Institute of Nuclear Physics (SINP) will be ready for commercial application by mid 2001. This was declared by Atomic Energy Commission (AEC) Chairman Dr. R. Chidambaram, participating in the SINP golden jubilee celebrations. The cyclotron, which will develop radioactive isotopes for medical purposes, will enable sophisticated treatment of cancer and heart diseases, within the reach of common man. Since isotopes have to be imported at great cost, the cyclotron will result in substantial saving of foreign exchange. And by exporting these isotopes, India will in fact be able to earn foreign currency. The cyclotron is touted as a prime example of nuclear physics. It is being developed by SINP and West Bengal Radio pharmaceuticals Ltd.

Insat-3B will launch Sat phones

India's own satellite-based mobile telephony services may become operational with the launching of Insat-3B satellite early this year, secretary of Department of Science and Technology (DST) VS Ramamurthy said. The satellite, first in the Insat-3 series, is scheduled for launch in February this year from Kourou in French Guyana using a launch vehicle of French Company Ariane-space. A satellite-based communication network for rural development, administration and poverty alleviation programmes had also been proposed.

Remote-Controlled Vehicle

The Centre for Artificial Intelligence and Robotics (CAIR) is developing a remote-controlled tracked vehicle to help boost anti-terrorist, border reconnaissance, law and order operations for Indian defence and police forces. The remote-controlled vehicle called the Articulated Tracked Vehicle (ATV), is aimed at functioning in hazardous environments like reconnaissance in hostile regions in border areas, bomb defusion and riot control to avoid endangering lives of security personnel. Though the currently developed prototype ATV is only mounted with a camera, the aim of the project is to develop an ATV with on-board guns to provide firepower when used in border areas against infiltrators. Similarly, an adaptation of the ATV for law and order forces in the country would be attached with a long arm for safe removal and defusion of bombs placed by terrorists and water cannon for riot control. The ATV can be remotely controlled from bunkers, miles away and the operator can control it with the help of a mounted camera which facilitates guiding the vehicle through oough terrain. The camera also provides the operator with the view of different targets. Controlling the ATV is made simpler as the video feedback is through a radio modem as radio waves can penetrate solid obstacles like walls and structures. This enables control of the system by an operator who is physically miles away with the help of a joystick and the on-board camera. The video and joystick signals are transmitted by an antenna. Further research is aimed at adding more intelligent facilities to make the ATV smart and autonomous in a limited way under the control of the operator.

Supercomputer to probe genetic secrets

International Business Machines Corp plans to build a supercomputer to study how proteins are formed and their role in human diseases. The plan envisions a new RS/6000 computer, named 'Blue Gene', capable of more than 1 quadrillion operations a second, or 100 times more powerful than 'Deep Blue', the machine that beat world chess champion Garry Kasparov in 1997.

The Blue Gene supercomputer will be used to create three-dimensional models of how proteins fold, giving scientists and doctors better insight into diseases and ways to combat them. Projected to be 500 times faster than the most powerful supercomputers, Blue Gene would help pharmaceutical companies design prescription drugs customised to the needs of individuals. It would allow doctors to respond rapidly to changes in bacteria that lead to drug-resistant viruses, induding HIV. IBM's breakthrough technology under taking would build on the roadmap being created by the Human Genome Project, an initiative that has set a goal of deciphering the entire human genetic code by 2005.

Bacteria found in deep Antarctic ice

Biologists have been surprised finding evidence of bacteria deep in Antarctic ice above a freshwater lake that lies beneath the thick frozen surface. Two teams of scientists found evidence of bacteria living in

ice above Lake Vostok, a subglacial body of water, the size of Lake Ontario that is one of the deepest bodies of water on Earth and is located more than two miles under the East Antarctic ice cap. From a biologist's perspective, this is the 'Holy Grail of Lake biology', said John Priscu of Montana University, who led one of the two groups. The bacteria are similar to those known as proteobacteria and actinomycetes, which are usually found in soil. The existence of such 'extremophiles' in Lake Vostok and elsewhere has given scientists hope that life could exist in similarly forbidding conditions on other planets. For example, one of Jupiter's moons, Europa may have frozen oceans.

New Sweeteners

Thirteen new sources of natural sweeteners from various plants found mostly in the Himalayas have been identified by the scientists at the Indian Institute of Sugarcane Research, Lucknow. Newly discovered non-saccharide sweeteners 100 to 10000 times more sweeter than sucrose. The herbal sweeteners do not have any adverse impact on health which is common problem of synthetic sweeteners like saccharin, aspartance and cyclamate. These are used as alternatives to sugar.

Five types of herbal non-saccharide sweeteners good for health, terpenoids, steroidal, saponin, dihydrochalcocene and dihydroisocoumarires are produced in plants during food generation process as byproducts and these are used by plants to fight pathogens.

New Atomic Clock

Termed NIST F-1, the new cesium atomic clock at NIST's Boulder, Colo, has the distinction of being the most accurate clock in the world. NIST's F-1 is referred to as a fountain clock because it uses a fountain-like movement of atoms to obtain its improved reckoning of time. First, a gas of cesium atoms is introduced into the clock's vacuum chamber. Six infrared laser beams then are directed at right angles to each other at the centre of the chamber. The lasers gently push the cesium atoms together into a ball. In the process of creating this ball, the lasers slow down the movement of the atoms and cool them to near absolute zero. The two vertical lasers are used to gently toss ball upward (the 'fountain' action) and then all of the lasers are turned off. This little push is just enough to loft the ball about a metre high through a microwave-filled cavity. Under the influence of gravity, the ball then falls back down through the cavity. The entire round trip for the ball of atoms takes about a second. At the finish point, another laser is directed at the cesium atoms. Only those whose atomic states are altered by the microwave cavity are induced to emit light, known as fluorescence. The photons emitted in fluorescence are measured by a detector. This procedure is repeated many times while the microwave energy in cavity is tuned to different frequencies. Eventually, a microwave frequency is achieved that alters the states of most of the cesium atoms and maximizes their fluorescence. This frequency is the natural resonance frequency for cesium atom-the characteristic that defines the second and, in turn makes ultraprecise time keeping possible.

India's First Linux Supercomputer

A NRI from Bangalore has developed India's first commerical supercomputer based on the Linux operating system, that costs just a fraction of what a conventional 'Cray' does. Mahesh Jayachandra (37), who has built two models of a super-computer. The two models—'Peacock and Maya'—will cost between 5 lakhs and Rs. 10 lakhs each while a Cray costs nearly 10 million dollars (about 50 crore). He explains, 'Standard benchmarks have demonstrated that Peacock and Maya achieve performances comparable to super-computers costing millions of dollars.

Jayachandra, a neurophysiologist, currently associated with the physiology department of St. John's Medical College at Bangalore. Linux based supercomputers have been developed and are being used widely by universities and other agencies in U.S. But it is for the first time that a similar system has been developed in India and is being made available for sale. A supercomputer that is capable of handling large scale computing at breakneck speeds has a wide range of applications in many areas, including defence, space, medicine, meteorology and the Internet. Linux is a 32-bit multi-tasking, multi-user operating system that runs on most computers and interoperates well with other systems like Apple, Microsoft. To develop and market the supercomputers, Jaya-chandra has incorporated Peacock Solutions Private Limited as the wholly Indian subsidiary of the New York-based NRI group's Peacock systems.

Male Infertility

Nearly 3% of men are sterile. This can be caused by environment or genetic factors. The environmental causes are relatively well understood, but much less is known about the genetic ones. Men and males of other mammalian species have both X, and Y chromosomes, unlike females, who have two X chromosomes. The major function of the Y chromosome is to determine maleness. One of the hallmarks of being male is the production of sperm, and the Y chromosome contains a number of genes for the constituents of sperm. If any of these critical genes are disrupted, sterlity can result—either from defective sperm, or the complete lack of them—although males with such mutations might be otherwise healthy. One of these conditions is '*Azoospermia*', in which a male makes no sperm. Mutations the remove large pieces of DNA within the Y chromosome—known as 'deletious'—have been associated with *Azoospermia*, but precisely which gene or genes within a particular region cause the defect was unknown. A group of geneticists Sun, Skaletsky, Birren, Devon, Tang, Silber, Oates have now located the first 'Azoospermia gene' on the Y chromosome. They have described the identification of the gene as '**USP9Y**', within one of the large regions of the Y chromosome. While screening a large population of infertile men, the researchers noticed that one of the men had a mutation in USP9Y that stopped the gene from functioning and caused Azoospermia.

●●●

Latest General Knowledge

ABBREVIATIONS

IASM—Indian Association of Sports Medicine

Sports medicine specialist, Dr. P. S. M. Chandran has been elected the president of IASM. Sanjeev Sahni of Sports Authority of India was elected secretary of the association.

SITA—Studies in Information Technoiogy Applications

The World Bank-aided programme—SITA aims to train socially disabled women in computer skills to help them earn a livelihood. The idea behind the project is 'Educating a man is educating an individual; Educating a woman is educating a family.'

AWARDS

Roosevelt Medal—The agricultural scientist, Dr. M. S. Swaminathan, has been nominated for the Franklin D. Roosevelt Four Freedoms Medal in 2000.

The Franklin and Eleanov Roosevelt Institute, in its communication to Dr. Swaminathan, said his extraordinary work as an agricultural scientist leading the Green Revolution and bringing hope to the people of the developing nations.

Financial Express Award—The Punjab Governor, Lt. Gen. (Rtd.) J. F. R. Jacob presented the 'Financial Express Award for Economics 1999' to the former member of Planning Commission and renowned economist Prof. B. S. Minhas.

Union Home Minister's Award—The prestigious Union Home Minister's Award for Forensic Science for 1998 has gone to Mr. T. R. Nehra, a distinguished forensic scientist as Principal Scientific Officer in the Central Forensic Science Laboratory of the Central Bureau of Investigation' (CBI). Mr. Nehra has been honoured with the award for his contribution in the field of forensic documents examination which won him international recognition.

Jakanachari Award—Mr. K. Shamaraya Acharya of Karkala has been chosen for the Jakanachari Award for 1999, which is given to persons in recognition of their outstanding contribution to sculpture.

Lata Mangeshkar Award—Well-known playback singer S. P. Balasubramanyam has been chosen for Lata Mangeshkar Award 1999 for his invaluable contribution to the field of music. The coveted annual award was instituted by the Madhya Pradesh Government for exceptional contribution to the field of light music.

Literary Award—Noted Assamese writer Ajit Barua will receive the prestigious Assam Valley Literary Award for 1999. Barua had earlier received the Sahitya Akademi award for his poems in 1991.

Safety Award—Wagodhia plant of Gas Authority of India Ltd. (GAIL) has received the Safety award from Gujarat Safety Council and Gujarat factory inspectorate in category II, group C for the year 1997 for their performance in industrial safety. GAIL had earlier bagged this award in 1996 also.

Millennium Award—Dr. A. N. Rai, Director of Extension, Ministry of Agriculture, has been conferred the India 2000 Millennium Award for his contributions to the art and science of communication in the areas of agriculture, education and environment. It has been jointly given by the International Association of Educators for World Peace and the World Institute Building Programme.

Diwaliben Award—The Minister of State for Social Justice and Empowerment, Mrs. Maneka Gandhi, is to be honoured with the 1999 Diwaliben Award for her outstanding contributions to the cause of vegetarianism. Mrs. Maneka was chosen for her abiding concern for human and animal welfare and her valuable work for the country.

Stree Shakti Puraskar—The Government has announced the institution of five national awards for women who excel in various fields. The awards—Stree Shakti Puraskar—each carrying Rs. one lakh in cash, have been named after Devi Ahilya Bai Holkar, Kanngi, Mata Jijabai, Rani Gaidenlou Zeliang, and Rani Lakshmi Bai, eminent personalities in the Indian history known for displaying personal courage and integrity. The awards will be presented on the occasion of the International Women's Day on March 8.

The idea to institute awards, was to counter the glorification of Sati by some elements and project the positive side of the contributions and achievements by women.

Indira Gandhi Rajbhasha Award—The Tehri Hydro Development Corporation Ltd. (THDC) has received the Indira Gandhi Rajbhasha Award for 1998-99. Mr. M. L. Gupta, Chairman and managing director of THDC received the Rajbhasha Shield in the category of PSUs for outstanding work performance of officlal work in Hindi.

NTR Award—Lata Mangeshkar, the melody queen of Indian cinema has been selected for the N. T. Rama Rao National Film Award for 1999 for her outstanding contribution to the growth and development of Indian cinema.

National Mineral Awards 1998—National Mineral Awards 1998 have been given to nine eminent geoscientists.

The award winners include Mr. Rabindra Nath Patra, Senior Geologist with the Geological Survey of India (GSI) for making a significant contribution towards system exploration of Platinum group of elements in Baula-Naushi pocket of Orissa. Mr. C. P. Sisodia, Director (Geology) of the GSI received the award in association

with Mr. A. K. Chattopadhya, also a Director at the GSI, for making a significant contribution in identifying the second largest lead-zinc deposit in Kayar in Ajmer district of Rajasthan. Dr. D. C. Panigrahi, Professor Indian School of Mines has been awarded for his work in underground mines ventilation engineering and design of work place environment in underground mines, including the heat and humidity problem.

Another recipient is Dr. C. Srikantappa, Professor, University of Mysore, for making a significant conribution in identification of high pressure Nilgiri granulites. Another awardee is Mr. Mohamad J. Ahmed, Senior Geologist with GSI for his contribution in the Narmada Sagar Mega Project. Mr. C. V. R. Sarma, Scientific Officer in Atomic Mineral Division has received the award in association with Mr. R. Sreehari, also Scientific Officer in the same division, for contributing in designing a compact high-sensitivity Note Book Personal computer based Air-borne Gamma Ray Spectrometric survey system.

Yet another recipient is Mr. Amit Bhusan Dutt, Deputy Director General of GSI for his contribution in developing exploration models for coal and lignite deposits which were successfully tested in the southern part of Godavari valley and Thanjavur.

Gandhi Peace Prize—The President, Mr. K. R. Narayanan presented Gandhi Peace Prize 1999 to Baba Amte. The award carries a cash prize of Rs. 1 crore and a citation. The President said Baba Amte's life and activities have been animated by the constructive programme devised by Mahatma Gandhi for attainment of independence for India.

Polar Music Awards—Singer–song writer Bob Dylan and violinist Isaac Stern have won Sweden's Polar Music Award, dubbed the nobel prize for musicians. The international prize awarded by the Royal Swedish Academy of Music, has been given to musicians since 1992.

International Film Festival of India–2000 Awards—The Malyalam film-maker Jayraj, whose film 'Karunam' shared the Golden Peacock Award for the best film by an Asian director with the Japanese film 'Poppaya' at the 31st International Film Festival of India–2000.

The Chinese entry for the competition, 'Postmen in the Mountains' was picked up for the Special Jury Award which also carries a Silver Peacock and Rs. 2·5 lakhs. This film was directed by Huo Jianqi.

Golden Peacock Innovative Management Award—Indian Oil's Mathura refinery has been awarded the prestigious Golden Peacock Innovative Management award for 1999. It was the second time the refinery was bestowed with a prestigious award, Earlier, it had received the United States Malcolm Baldrige national quality award and Deming prize of Japan.

Screen-Videocon Awards—'Nayi Disha', a non-film music album penned by Prime Minister Atal Behari Vajpayee, has been nominated in four categories of the coveted Screen-Videocon Awards this year.

The album, based on Vajpayee's collection of poems, has been nominated for the best non-film album, best lyricist (Atal Behari Vajpayee), best singer (Jagjit Singh) and best composer (Lataji Premji and Jagjit Singh) Released by HMV, Nayi Disha became the third highest selling album for the year in the non-film category.

Republic Day Awards

Following are the eminent recipients of the awards on the 51st Republic Day.

Padma Vibhushan—Eminent writer R.K. Narayan, Chief Election Commissioner Dr. M.S. Gill, ISRO chairman Dr. K. Kasturirangan, Former Union Minister Mr. Sikander Bakht, noted economist Prof. Jagdish Bhagwati, Prof. K.N. Raj, Swami Ranganathananda of the Ramkrishna Mission, Mr. M. Narsimham.

Padma Bhushan—Film star Rajnikant, Eminent industrialist Mr. Ratan Tata, the former information advisor to Indira Gandhi Mr. H.Y. Sharada Prasad, noted Islamic scholar Maulana Wahiduddin Khan.

Padma Sri—Music director A.R. Rahman, film director Shekhar Kapoor, film actress Hema Malini, film producer and director Ramanand Sagar and Prof. G. L. Bondarevsky of Russia, Ms. Janaky Athinahappan of Malaysia and S.N. Gourisaria of U.K.

Ashok Chakra—Ashok Chakra has been awarded posthumously to Maj. Sudhir Kumar of 9 Para (special force) for his gallantry in counter-insurgency operations in Jammu and Kashmir, while Mahavir Chakra, the nation's second highest war-time gallantry award, has been awarded to sepoy Imliakum A.O. of the second battalion of Naga Regiment for his role in Kargil operation.

Param Vir Chakra—Param Vir Chakra was presented to the parents of captains, Vikram, Batra and Manoj Kumar Pandey, both of whom got the country's highest gallantry award posthumously, as also to Rifleman Sanjay Kumar and Grenadier Yogendra Singh Yadav for their gallantry during Kargil conflict.

EXHIBITIONS/ CONFERENCES/ SEMINARS/ FESTIVALS

World Conference on Ethnicity—The Punjabi University hosted an international conference on ethnicity in the First World, the Third World and ex-communist countries on January 6 to 8. The conference was organised in collaboration with the International Political Science Association's Research Committee on Politics and Ethnicity.

International Physics Conference—To mark the 75th anniversary of quantum mechanics, a science that changed human perception about nature in the 20th century, a three-day International Physics Conference was organised from December 28. It was attended by several distinguished scientists from all over world.

Human Unity Conference—The five-day 19th International Human Unity Conference concluded at New Delhi on January 2, 2000. Sant Rajinder Singh Maharaj said the body is a temple of God and living in the body is the soul, we should live like we are in a place of worship, in a temple of God, full of love that the whole world is enlightened.

Seminar on 'Indian No-Dig 2000'—The second national seminar and exhibition—'Indian No-Dig 2000'

on trenchless (no-dig) technology was held from January 20 to 22 at the Indian Institute of Technology, Delhi. The seminar was organised by the Indian Society for Trenchless Technology (INDSTT) in collaboration with ministry of urban technology, National Buildings Construction Corporation (NBCC), Ministry of Science and Technology, International Society for Trenchless Technology U. K. and Construction Industry Development Council (CIDC). The technology, commonly known as no-dig method of construction, is environment friendly and cost-effective. It is unique technique for laying, replacing and renovating of underground utilities such as power and telecommunication cables, sewage, water supply and gas pipelines etc. without digging the ground. The Government has appointed NBCC as a nodal agency for promotion of trenchless technology in the country.

Seminar on Earthquakes—The earthquakes seminar was inaugurated on January 6, 2000 in the Institution of Engineers (India), Roorkee Local Centre Auditorium by Mr. V Suresh, Chairman-Cum-Managing Director, HUDCO, New Delhi. Several internationally-famous scientists were present. The seminar is sponsored by University of Roorkee, Oil and Natural Gas Commission, New Delhi, DCBR, Roorkee, CSIR, New Delhi.

International desert kite festival—The fourth international desert kite-festival held on January 14, 2000. Participants from USA, UK, France, Japan etc. attended. The international desert kite festival was organised by the Department of Tourism.

Cardiovascular conference—About 400 Indian and Asian Cardiologists were able to see a live operation taking place in hospital in Italy. During the procedure, they were also be able to ask questions to the Italian experts. All this was possible sitting in the New Delhi. G. B. Pant Hospital held a three day Conference on trans-catheter cardiovascular interventions from January 26 to 28.

DAYS

January 12—National Youth Day
January 15—Army Day
January 26—International Customs Day and Republic Day of India.
January 30—Martyr's Day.

BOOKS

Speed Post—Written by Shobha De.

Inside Diplomacy—Written by Kishan S. Rana.

Pakistan under Musharraf—Written by Sulakshan Mohan.

Cricket World Cup 1999—Written by Pradeep Mandhani.

Issues and Themes of Indian Politics—Written by S. N. Balasundaram.

My Search My Evolution—Written by Laxman Pai.

Kalidasa's Image of Nature—Written by M. Fahimuddin.

Kal Khand—Written by P. C. Katoch.

Third World in the Age of Globalisation—Written by Ash Narain Roy.

Kargil : A soldiers Diary—Written by Harinder Baweja.

Harvesting Our Souls—Written by Arun Shourie.

DEATH

Curtis Mayfield—Rhythm and Blues legend Curtis Mayfield, whose music helped define the Chicago sound in the 1960s, died on December 26. He was 57. A member of the Rock and Roll Hall of Fame. Mayfield's hits included the sound track from 'Superfly', the seminal singles 'People Get Ready and Keep on Pushing.'

Ali Mian—Islamic scholar and All-India Muslim Personal Law Board (AIMPLB) chairman, Maulana Syed Abul Hasan Ali Nadvi, popularly known as Ali Mian died on December 31.

T. N. Kaul—Mr. T. N. Kaul, former foreign secretary, who also served as India's ambassador to the US as well as erstwhile USSR, died on January 16 after a fall in his home at Rajgarh in Himachal Pradesh. He was also vice-chairman of Indian Council for Cultural Relations (ICCR). Kaul was the author of several books on foreign policy. He was 82.

M. A. Chidambaram—A doyen of South Indian industry, M. A. Chidambaram died at Chennai. He was a multi-faceted personality, whose activities encompassed fields such as the arts, Tamil language, education, health and philanthrophy.

Robert Wilson—American Atomic physicist Robert Wilson, who had a leading role in developing the atomic bomb during World War II, died on January 16, from complication due to a stroke. Wilson, an expert on particle accelerators, or cyclotrons, worked with Enrico Fermi on the secret Manhattan project that built the World's first atomic bomb.

PERSONS IN THE NEWS

Mr. Boris Yeltsin—Russia's President Mr. Boris Yeltsin resigned on December 31, 1999, six months ahead of his constitutional term, appointing Prime Minister. Mr. Vladimir Putin as acting President and urging Russians to vote for him in early presidential elections. Mr. Putin also assumed as Commander-in-Chief of the armed forces and received the so-called 'nuclear briefcase' with codes controlling the country's nuclear arsenal.

Mr. T. S. Krishna Murthy—Mr. Murthy, Secretary, Department of Company Affairs, is the new Election Commissioner in place of Mr. G. V. G. Krishnamurthy, who retired on September 30 last. Mr. Krishna Murthy is a 1963 batch Indian Revenue Service (IRS) officer and will have a tenure of more than five years in the E. C.

Goh Chok Tong—Goh Chok Tong visited India in the third week of January. In his earlier visits to India, the Singapore Prime Minister had underlined the imperatives of establishing closer political and economic links between the two countries. The Indian leaders, in turn, has recognised the importance of Singapore, not only in bilateral terms but also as a 'window' to the other countries of South-East Asia.

PLACES IN THE NEWS

Kandhar—The city in Afghanistan which was in the news when the

hijacked Indian Airline plane was taken there. It is the base of Mullah Umar.

Katchal—The island in Andman and Nicobar was declared by the Greenwich observatory as the first place on earth to witness the millennium sunrise.

MISCELLANEOUS

Gandhi runner-up to Einstein in Time poll—Mahatma Gandhi has been named runner-up to noted physicist, Albert Einstein, as the person of the century by Time magazine. Gandhi was selected as the runner-up alongwith U. S. President Franklin Delano Roosevelt, by the renowned magazine in its 'People of the Century Project'.

Decks cleared for Rajasthan power project—Decks have been cleared for establishment of the second wind-based power project in Rajasthan with the assistance of the Union Ministry for Non-Conventional Energy Sources, promising to improve the power situation in the State to a considerable extent. The 2·25 MW power plant will be set up in Deogarh village in Chittaurgarh district, for which the State Government has given formal sanction and allotted 16·70 hectares land free of cost to the Rajasthan State Power Corporation Limited.

The first wind-based power project of the State was set up in Amarsagar in Jaisalmer district, and started functioning, before schedule, in August this year.

World's youngest Microsoft certified system engineer—Ruchir Jain has become the youngest Microsoft certified system engineer of the world. Ruchir Jain, just 13, a student of class 8 of M. G. Public School, Muzaffarnagar (U.P.) has received this honour after passing one of the toughest Microsoft Certification System Examination (MCSE). Ruchir got his certificate of excellence, which has been signed by Mr. Bill Gates himself, the most famous personality in the field of computer. Ruchir received this honour only in 88 days and has made India proud.

India is largest producer of milk—India is all set to retain its position as the World's largest milk producer in 1999-2000 with the output expected to touch the 781 lakh tonnes mark, up from 747 lakh tonnes last year.

The large increase in milk production was the result of strengthening the extension of frozen semen technology, progeny testing and national bull production programme resulting in genetic upgradation of cows and buffaloes. India is also fifth largest producer of eggs, sixth largest producer of fish and second in inland fisheries, an official release said.

Honorary Fellowship—The All-India Institute of Medical Sciences (AIIMS) has decided to confer an honorary fellowship on Dr. Gro Harlem Brundtland, Director-General of the World Health Organisation (WHO), Geneva, and the author of every environmentalists handbook, 'Our Common Future'. During the last 43 years, since its inspection, this is the fourth time that the AIIMS has decided to confer such a fellowship on an internationally renowned expert.

Earlier, this fellowship was conferred upon the Nobel laureate Hargobind Khurana, the former Irish President, Dr. Patrick John Hillery and former Prime Minister of Mauritius, Dr. Sir Seewoosagar Ramgoolam.

New President for Marshall Islands—The Marshall Islands elected a new President when Members of the Nitijela (Parliament) unanimously voted in three-term Speaker Kessai Note to replace Imata Kabua. Note, who as Speaker successfully battled the former President and his ruling party for two years, became the third President of the Marshall Islands since this north Pacific nation began constitutional government in 1979.

Novelist of the century—The author of the timeless classics, 'Charitraheen' and 'Grihadaha', Sarat Chandra Chatterjee, has been chosen novelist of the century in an online poll conducted by a literary magazine. He is followed by Bhagwan S. Gidwani, R. K. Narayan and Munshi Premchand.

Nepal orders expulsion of Pakistan diplomat—The Nepalese Government has ordered expulsion of a junior diplomat of the Pakistani Embassy in Kathmandu for his alleged involvement in counterfeit Indian currency dealing. Wassim Saboor was allegedly caught with fake Indian Bank notes worth Rs. 50000, while trying to sell them to a Nepalese Government agent.

Jaipur boy becomes Microsoft database administrator—A teenager has accomplished a rare feat by becoming youngest Microsoft Certified Database Administrator (MCDBA) and Microsoft Certified Solution Developer (MCSD). Govind Jajoo cleared both the exams. Govind, who is at present a second year graduation student of the University of Rajasthan. He is already the youngest Microsoft Certified Professional (MCP), with Internet specification and Microsoft Certified System Engineer.

Gujarat-born on US Congressional panel—A Gujarat-born Nisha Desai has joined the Democratic professional staff of the powerful US House of Representatives International Relations Committee, becoming the first Indian American to serve on the panel. Nisha Desai is required to serve all the Democratic members of the Committee, and reports directly to Sam Gejdenson, the ranking minority member of the panel. She covers South Asia issues as well as budget and oversight of the State Department, the US Agency for International Development (USAID) and the United Nations. She also works for refugee assistance and humanitarian relief.

World's biggest hydel plant—The World's biggest hydroelectric power plant capable of lighting up the entire east will be set up at Dihang and Subansiri in Arunachal Pradesh. The Power Minister, Mr. P. R. Kumaramangalam told newspersons at Guwahati, that the project is expected to generate 21000 MW, and will have three units each.

Sonia Gandhi to be replaced as IGNCA Chief—The Government recast the board of trustees of the Indira Gandhi National Centre for Arts (IGNCA) and appointed a new Member Secretary, who will conduct fresh elections for the president's post shortly. Mrs. Gandhi's term as president is deemed to have lapsed in 1997 as the amendment introduced to the IGNCA'S Trust. Deed making her president for life has been found ultra vires. According to legal advice obtained by the government, the amendments introduced to the IGNCA trust's original deed in 1995 were ultra vires and thus were liable to be ignored. The Delhi High Court had in September asked the government to take appropriate action after hearing its petition, challenging the legality of the amendments. The new member-secretary, Dr. N. R. Shetty, is a former V. C. of Bangalore University. Of the 19 trustees, 12 had retired, two had died and one had resigned. Of the earlier trustees, only four have been retained. They are Mrs. Sonia Gandhi, Mr. P. V. Narasimha Rao, Prof. Yashpal and Dr. Abid Hussain. The new-look list figures vocalist Pandit Bhimsen Joshi, journalist M. V. Kamath, Indologist Vidya Niwas Mishra, educationist H. Narasimahiah, film director Aparna Sen, painter Anjolie Ela Menon, singers Bhupen Hazarika and K. J. Yesudas, dancers V. S. Sharma and Sonal Mansingh, former ambassador L. M. Singhvi and agricultural scientist M. S. Swaminathan.

Film festival—The first international film festival of the new millennium, 31st International Film Festival of India opened on January 10, 2000 at New Delhi. India enjoys the honour of hosting the millennium's first cinema festival. The Film Festival opened with Cuba's film 'Life is to Whistle'.

Chamera project—Work on the prestigious 300 mW Chamera hydroelectric project (Stage-II) in the Chamba district has been undertaken on a war footing so as to complete within scheduled five years. So far 600 metres of excavation job in the underground power house tunnel, tail race tunnel, Adit-I and II tunnel has been completed within four months. The Rs. 1682 crore project is being executed on the Ravi river. The efforts were on the speed up the construction work of the project to complete it within its five-year schedule.

India's first medical portal—Dr. Reddy's Laboratories Ltd. and IIQ investments have launched India's first medical community portal, mediatimes, Com, which is designed to serve the country's medical doctors. Mediatimes Com provides doctors with round the clock online access to the latest medical information, regular updates, links to powerful medical knowledge resources and reputed journals. In addition, it allows doctors networks to facilitates exchange of ideas, experiences and information.

R-Day Chief guest—Nigeria's President Olusegun Obasanjo was the chief guest at the Republic Day celebrations this year. The President, a former army general who handed over power to a civilian government, was a political prisoner during Abacha's military rule. He is passionate about democracy and played a decisive role in getting Pakistan out of the Committees of the Commonwealth in Durban. Obasanjo led the campaign by African and Pacific island states not to allow some Western countries adopt a 'softer' approach.

SPORTS

IOA honours Dhyan Chand, P. T. Usha—Hockey Wizard Dhyan

(Continued on Page 18)

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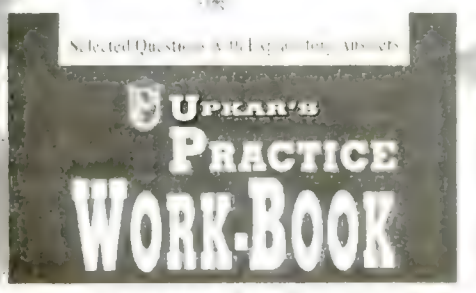

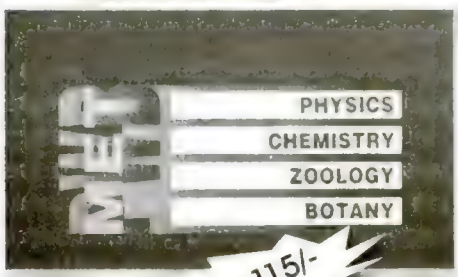

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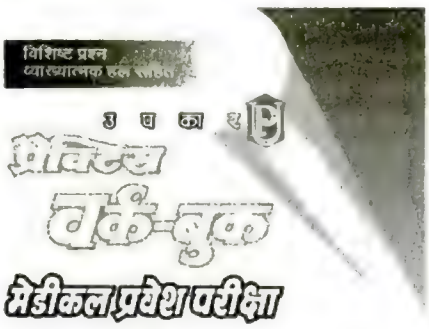

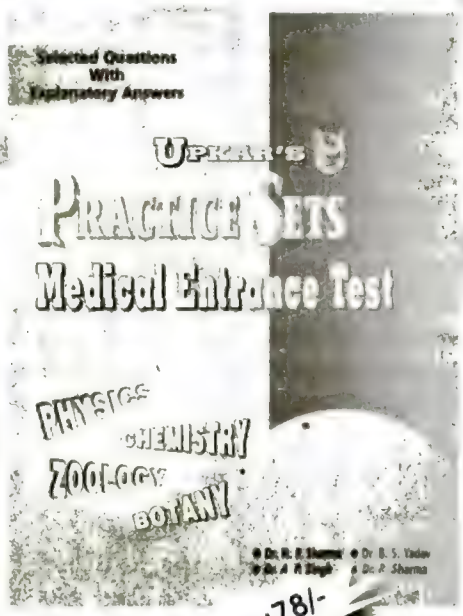

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SELECTED QUESTIONS WITH EXPLANATORY ANSWERS

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MILESTONES OF SCIENCE

Bovine pregnancy :

Scientists at the G.B. Pant University of Agriculture and Technology have developed a special chemical, which can detect pregnancy through milk within 20 days after insemination.

This would be welcomed by the livestock farmer who had to wait for months to know if his animal was pregnant. The kit is a reagent. Coated strip which changes colour, in case of pregnancy. It will be soon available for field use.

Lifetime immunity :

Chickenpox may not be fatal, but if parents want to take no chance of their child contacting the disease, there is a vaccine that guaranties lifetime immunity against the disease. The Varicella vaccine is expensive, with one shot costing Rs. 1400. Just one shot is enough to make a child immune to chickenpox for his entire life. The success rate of the vaccine is said to be 98 per cent. Chickenpox is a mild disease and is not fatal except in very rare cases. In United States, it was included in the national immunisation programme since 1997. Varicell vaccine is absolutely safe vaccine which can save child from complications due to chicken pox in cases where it occurs after the age of 15. If a child contacts chickenpox before one year or after 15 years of age, it can lead to several complications.

Ramplatzer device :

Doctors of Shri Jayadeva Institute of Cardiology, Bangalore, have successfully treated heart hole, a congenital defect, without any surgery by using a new technique called Ramplatzer device. The defect occurs due to faulty development of the wall which separates the and left sides of the heart. Till recently, the only remedy was open heart surgery, involving the opening of the chest wall and blood transfusion, leaving a scar on the chest wall. Doctors of Institute said the device would be introduced through the leg vein under X-ray guidance and deployed at the site of the hole, to be followed by corrections if needed. The advantage of this unique technique is that there is no need of blood transfusion and it will not leave any scar on the chest wall. The whole process can be done under local anaesthesia and the patients are required to stay in the hospital only for three days. They can resume normal activity soon after the discharge from the hospital.

Trenchless technique :

The National Building Construction Corporation (NBCC) has introduced the 'trenchless technology' in the country, which facilitates laying of underground pipelines, sewers and cables without digging up the surface of earth. Urban Development Minister inspected the use of this technique at a site in Cannaught Place in the capital, where NBCC is carrying out the task of laying underground pipelines for the Mahanagar Telephone Nigam (MTNL). The trenchless technique has the advantage of being environment friendly and cost effective. It is a unique method of laying, replacement and renovation of underground utilities, such as sewer lines, electric cables, water and gas pipes. It ensures that there is no traffic obstruction, accidents or extra costs in providing diversions. NBCC has already executed numerous jobs with it for the DVB, MTNL, NDMC and PWD.

De-addiction :

A British company is leading the clinical trials of a new vaccine to cure addicts of two of the most addictive drugs—cocaine and nicotine. The new treatment works with a course of three injections spaced a month apart. Previous treatments for both cocaine and nicotine injections have relied on the use of substitutes used as aids to reduce the level of dependency. None of these treatments have proved totally effective and the replace rate is high.

Water purification using diamond electrodes :

The Fraunhofer Institute for Thin Films and Surface Engineering in Germany is producing diamond electrodes that hold immense potential for water purification. At the laboratory, substrate of graphite, metal or ceramics are coated with a fine but extremely stable diamond layer, which is doped by adding boron and as a result becomes electrically conductive. The coated parts make an excellent material for electrodes as they are more resistant to corrosion and wear than conventional electrodes and can withstand much higher current densities. Due to their extremely high stability and the fact that they do not easily electrolyse water. Diamond electrodes are especially well suited to the conversion of organic molecules, according to scientists at the institute.

Disinfection and the breaking down of organic toxic materials are the key issues in the purification of drinking and waste water. Polychlorinated hydrocarbons, for example, are very stable and often resistant to microbiological decomposition. Diamond-coated electrodes enable such compounds to be destroyed in electrochemical processes without harming the environment in any way. Germs are also eliminated during electrolysis. Under high voltages the water molecules break up and oxygen radicals are formed. These in turn combine to form ozone, which destroys microorganisms.

Robot nurses for sick, elderly :

Robot nurses may soon be helping the sick and elderly by telling them when to take the medicine pills and recording their temperature and pulse. Engineers from the University of Pittsburgh and Carnegic Mellon University (CMU) in Pennsylvania have designed a new generation of robots to make life easier for the elderly and housebound and to inform their doctors of any medical

(Continued on Page 18)

MEMORABLE POINTS

- Astronomical unit is the mean distance of the earth from the sun. It is equal to ➡ **$1{\cdot}4960 \times 10^{11}$ m**
- The number of moles of a solute per litre of a solution is called ➡ **Molarity (M)**
- If a substance dissolves with absorption of heat, the solubility increases with rise in ➡ **Temperature**
- Par sec is the distance at which one astronomical unit subtends ➡ **An angle of 1 sec of arc**
- The property of a chemical substance which does not depend on the size of the sample is known as ➡ **Intensive property**
- A binary solution is composed of two components known as ➡ **Solute and solvent**
- The approximate limits of visible spectra are ➡ **From 4000 Å to 8000 Å**
- The measure of the force of attraction of the earth acting on an object is termed as ➡ **Weight**
- What deals with the effect of environment on genetic set up of organisms ➡ **Ecological genetics**
- The ratio of e.m.u. of charge to e.s.u. of charge is ➡ **3×10^{10}, the magnitude of speed of light in free space**
- On the Kelvin Scale, the temperature at which the volume of a gas becomes zero, is known as ➡ **Absolute zero (0K)**
- When F_1 individuals are crossed with homozygous dominant parent, the type of cross is said to be ➡ **Out cross**
- Heat can be directly converted to electrical energy with the help of ➡ **Thermocouple**
- A metal which melts at 30°C is ➡ **Gallium**
- The gill-slits, in the developing human embryo, illustrates the approval or evidence of ➡ **Recapitulation theory**
- When a ray of light enters into a glass slab from air its wavelength ➡ **Decreases**
- An organic compound that contains the divalent group $>C{=}NH$, is known as ➡ **Ketimine**
- In mammals the nucleus pulposus is found within ➡ **Intervetebral disk**
- The ratio of the velocity of a body to the velocity of sound is called ➡ **Mach number**
- The property of a system which depends only on the state of a system, not on the path used to get that state, is known as ➡ **State-function**
- A compound having the simplest formula which gives minimum information about that compound is known as ➡ **Empirical formula**
- Energy stored in a stretched wire per unit volume is ➡ $\frac{1}{2} \times$ **stress** $\times$ **strain**
- When a set of orbitals has same energy, the orbitals are known as ➡ **Degenerate orbitals**
- Availability of two kinds of leaves on the same plant is called ➡ **Heterophylly**
- Pascal and weber are the units of ➡ **Pressure of Magnetic flux respectively**
- The relative ability of an atom to draw electrons in a bond towards itself is called ➡ **Electronegativity (EN)**
- The spirally coiled membranous tube, the Cochlea, in the inner ear is concerned with ➡ **Sound reception**
- Diode is mostly used as a ➡ **Rectifier**
- When a molecule can be written by more than one satisfactory Lewis structure, the molecule is said to be ➡ **Resonance hybrid of these structures**
- The percentage of carbohydrates and protein in potato is ➡ **23% and 1·6% respectively**
- When a ray of light enters a glass slab from air its frequency ➡ **Remains same**
- Boiling point of a liquid can be changed by ➡ **Changing the pressure**
- Musical sounds are characterised by ➡ **Loudness, pitch and quality**
- N-type germanium is obtained by doping intrinsic germanium with elements like ➡ **Arsenic**
- When liquid flows through a horizontal pipe of variable cross-section, the pressure is large where cross-sectional area is ➡ **Large**
- Melting point of ice is decreased with the ➡ **Increase of pressure**
- When some amount of gas expands isothermally, the amount of work done is ➡ $\mu RT \log \frac{V_2}{V_1}$ **[$\mu \Rightarrow$ Mole number]**
- When the entire double slit arrangement for production of interference is dipped in water, fringe width will be ➡ **Narrow**
- Heat energy produced in the sun is due to ➡ **Thermonuclear reaction (nuclear fusion)**
- 1 GeV is equal to ➡ **$1{\cdot}6 \times 10^{-10}$ joule**

●●●

Examinations for Admission to Various Medical Institutes/Colleges

INSTITUTE OF MEDICAL SCIENCES BANARAS HINDU UNIVERSITY VARANASI—221005

Admission Notice for MBBS/BAMS/BDS/B. Pharma Course–2000

The Banaras Hindu University will hold an All India Combined Competitive written test (PMT/PAT) for admission to MBBS/BAMS/BDS and B. Pharma course on Sunday the 4th June, 2000 at Delhi, Varanasi, Calcutta, Chennai and Nagpur centres.

Eligibility—Qualifications—Passed Intermediate Science/Pre-Medical Course/12 years of 10 + 2 or equivalent examination with minimum of 50% marks (40% in case of SC/ST candidates) in English, Physics, Chemistry and Biology taken together. Uttar Madhyama students of Sampurnanand Sanskrit Vishwavidyalaya, Varanasi are eligible only for BAMS course. Candidates at the aforementioned qualifying examination may also apply.

Age—For MBBS/BAMS/BDS : Completed 17 years but not exceed 25 years on 31st December 2000 (Candidates born on or after 1st January 1984 need not apply).

How to obtain application form—Prescribed application form along with the Information Booklet can be obtained **By Cash :** On payment of Rs. 500/- (including bank charges, postal charges and examination fees) from the branches of the Banaras State Bank Ltd.

By postal channel—From the Office of the Director, Institute of Medical Sciences, Banaras Hindu University, Varanasi-221005 by sending a written request through Registered Post along with crossed Demand Draft/Bankers Cheque of Rs. 500/- of a Nationalized Bank, drawn in favour of 'The Director, Institute of Medical Sciences, BHU' payable at Varanasi. The request application must include the name and address of the candidate and full particulars of the enclosed demand draft. It should also be accompanied by two white paper self addressed slips of 10 cm × 6 cm size. The envelope containing requisition for application form and demand draft should be superscribed 'Request for Application form by post' Last date for requisition for PMT/PAT form by post is 22nd February, 2000.

Last date for submission of completed application form—Application forms duly completed must be sent through Registered Post, so as to reach **The Controller of Examination** (PMT/PAT cell), **Banaras Hindu University, Varanasi-221005**. Latest by 15th March, 2000.

RAJASTHAN PRE-MEDICAL AND PRE-VETERINARY TEST

The combined entrance test for admission to MBBS/BDS/BV & ASC for the session 2000-2001 will be held on May 24, 25, 26 and 27, 2000.

How to obtain application form—Prescribed application form along with information booklet can be obtained by sending stipulated fees from :

Manager,
Ingkol Cooperative Stores
M.B.M. Engineering College
Jodhpur (Rajasthan)
Pin Code–342011

Application forms can also be obtained from the Medical Colleges and Veterinary College of the state after paying cash price.

Last date for submission of completed application form :

Application forms duly completed will be accepted upto 18th March, 2000, at Jodhpur situated office of Examination Controller.

For detail description, see 'Rajasthan Patrika' dated 18th January, 2000. ●●●

(Continued from Page 14)

Chand and sprint queen P. T. Usha were named the Indian Sports persons of the Century by the Indian Olympic Association (IOA).

Dhyan Chand was gold medallist in the 1928, 1932 and 1936 Olympics. He led the side in the 1936 Berlin Games and had the distinction of scoring 11 of the 38 goals scored by the Indians there. He was awarded the Padma Bhushan in 1956.

Usha has won the highest number of medals for India in track field events, especially in Jakarta Asian Track and Field meet in 1985 and the Seoul Asian Games in 1986. She won the Arjuna Award in 1983 and Padmashree in 1985.

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(Continued from Page 16)

problems. 'Flo' the robot nurse, will remind people when to take their medicines and regularly check their vital signs—e-mailing the data to a doctor. At present Flo is an early prototype for a personal service robot which developers are design to help people. Flo is unique in the range of tools being developed to assist the elderly, according to Sebastian Thrun, an assistant professor of CMU's centre for Automated Learning and Discovery. It is a personal assistant as opposed to an intelligent wheelchair or smart walking aid. The engineers are also working on ways to enable the robots to open jars and bottles for arthritis patients. ●●●

SCIENCE TIPS

Physics

1. What is the resultant of a displacement 4 km North and the other 10 km East ?

   ➡ **10·78 km at 68·2° E of N**

2. When is the motion of a body said to be three dimensional ?

   ➡ **When the motion of a body occurs in space**

3. What is the inertia of motion ?

   ➡ **It is the property of a body to continue in its uniform motion along a straight line in absence of any external force.**

4. A flywheel starts from rest and speeds up uniformly, to 1200 rpm in 20 sec. What is the angular acceleration ?

   ➡ **2π rad/s^2**

5. When is a body said to be in equilibrium ?

   ➡ **When a body acted on simultaneously by several forces remains at rest or in motion it is said to be in equilibrium.**

6. What is 1 foot pound equal to in M.K.S. system ?

   ➡ **1·356 joule**

7. What is the C.G.S. unit of gravitation constant ?

   ➡ **cm^3 gm^{-1} sec^{-2}**

8. A metallic cube of side 10 cm is subjected to a shearing force of 900 kg wt. What is the shearing stress ?

   ➡ **8·82 × 10^6 dyne/cm^2**

9. How many gm of glycerine oil (density 1·26 × gm/cc) can be poured into a bottle which holds 247·2 gm of milk (density 1·03 gm/cc) ?

   ➡ **302·4 gm**

10. What are the dimensions of coefficient of viscosity ?

    ➡ **ML^{-1}T^{-1}**

11. What is the thermometric substance and approximate range of a thermocouple ?

    ➡ **Closed circuit of two dissimilar metals, 200°C to 1600°C**

12. When do the thermal stresses come into play inside a metallic rod ?

    ➡ **When the ends of a rod are rigidly fixed so that with change in temperature, the expansion or contraction of the rod is shoved off.**

13. Name this logic gate :

    ➡ **AND gate**

14. Which law of conservation is followed in nuclear reactions, electrification by friction and electrification by induction ?

    ➡ **Law of conservation of charge**

15. Name the majority carriers in semiconductors.

    ➡ **Holes in *p*-type and electrons in *n*-type**

16. 100 litre of air contain 1·5 g water vapour at room temperature. For complete saturation, the same volume of air requires 3·75 g water vapour. What is the relative humidity ?

    ➡ **40%**

17. What is the value of the gas constant ?

    ➡ **Gas constant R = 8·31 Joule per mole per °C**

18. What is conserved in a perfectly elastic collision ?

    ➡ **Both the momentum and the kinetic energy**

19. What is meant by diffusity ?

    ➡ **Diffusivity = $\frac{\text{Thermal conductivity}}{\text{Thermal capacity per unit volume}}$**

20. What is critical damping ?

    ➡ **It is a particular value of damping for which the simple harmonic motion just becomes non-oscillatory.**

Chemistry

21. 1/273·15 of the temperature interval between absolute zero and the triple point of water is known as

    ➡ **A kelvin**

22. The amount of the substance that contains as many entities as there are atoms in exactly 0·012 kg of carbon-12, is known as

    ➡ **A mole**

23. The amount of heat required to raise the temperature of one gm of water from 14·5°C to 15·5°C is known as

    ➡ **A thermochemical calorie**

24. When monosaccharides condense to for disaccharides, the linkage formed is known as

    ➡ **Glycoside linkage**

25. A polymer formed from a dialcohol and an aromatic diacid is called

➡ **Polyester, Dacron**

26. The natural rubber (Hevea rubber) is a polymer of

➡ **2-Methyl-1, 3-butadiene (isoprene)**

27. The synthetic rubber obtained by polymerization of 2-chloro-1, 3-butadiene is known as

➡ **Neoprene rubber**

28. A thermoplastic prepared by mixing 1, 1-dichloroethene and chloroethene is used as thin films to wrap food, it goes by trade name

➡ **Saran**

29. A common form of starch which has a branched chain arrangement of glucose units is known as

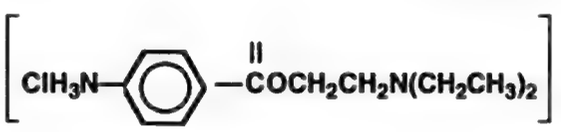
➡ **Amylopectin**

30. Conversion of alkanes into aromatic compounds by passing alkane vapour over a bed of Al_2O_3 containing Pt and Pd is known as

➡ **Catalytic Reforming**

31. The HCl salt of **Procaine** is used as most common local anaesthetic, the trade name of this anaesthetic is

➡ **Novocain**



32. The **'smell of death'** of decaying fish is due to two appropriately named amines as

➡ **Cadaverine**

$[NH_2—CH_2—CH_2—CH_2—CH_2—CH_2—NH_2]$

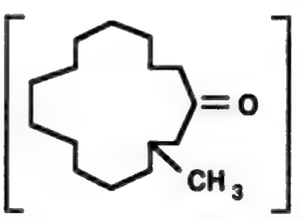
and

Putrescine

$[NH_2—CH_2—CH_2—CH_2—CH_2—NH_2]$

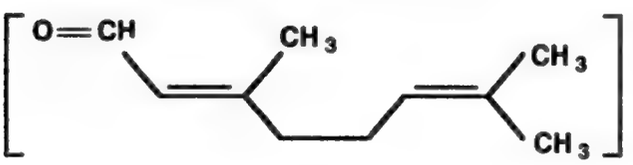
33. A ketone which is odoriferous component of musks is known as

➡ **Muscone,**



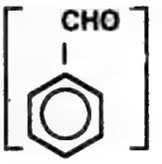
34. Chemical compound which is responsible for the characteristic odour of citral fruits is known as

➡ **Citral**



35. The compound which is responsible for characteristic odour of almonds is known as

➡ **Benzaldehyde**



36. The beewax is an ester of myricyl alcohol, the chemical composition of the same is

➡ **$[C_{15}H_{31}COOC_{30}H_{61}]$**

37. The candy bars contain fat based on saturated acid known as

➡ **Myristic acid $[CH_3(CH_2)_{12}COOH]$**

38. The same ion which can act both as a Bronsted acid and base is termed as

➡ **Amphiprotic**

39. Aluminium sulphate crystallizes from aqueous solution as $Al_2(SO_4)_3 \cdot 18H_2O$, is known as

➡ **Paper maker's alum**

40. The number of donor atoms bended to the central ion, is known as

➡ **Co-ordination number**

Zoology

41. The regulation of RBC production is accomplished by the harmone secreted by the kidneys

➡ **Erythropoietin**

42. A hormone released by the cortex of the adrenal gland that stimulates the kidneys to reabsorb sodium and excrete potassium

➡ **Aldosterone**

43. A nerve cell process that carries impulses toward the cell body

➡ **Dendrite**

44. Nerve tissue that contains unmyelinated nerve cells located in the brain and spinal cord.

➡ **Gray matter**

45. The serous membranes that lines the thoracic cavity and covers the lungs

➡ **Pleura**

46. A bond of connective tissue that attaches muscle to bone

➡ **Tendon**

47. Large fragment produced by initial process of protein hydrolysis

➡ **Peptone**

48. The cells that are embedded in the matrix of cartilage

➡ **Chondroblasts**

49. Bone developing within tendon of vertebrae particularly where tendon operates over ridge of underlying bone.

➡ **Sesamoid bone**

50. Tube connecting middle ear to pharynx in tetrapod vertebrates which allows the equalization of air pressure on either side of eardrum.
➡ **Eustachian tube**

51. Principal fibrous protein of the yellow fibres of animal connective tissue
➡ **Elastin**

52. A possible hominoid ancestor, a forest dwelling primate with some characteristics of living apes
➡ **Proconsul**

53. The process by which ATP production is tied to an electron transport system that uses oxygen as the final receptor.
➡ **Oxidative phosphorylation**

54. A connective tissue in which the cell lies within lacunae embedded in a flexible proteinaceous matrix.
➡ **Cartilage**

55. A part of a neuron that conducts impulses form the cell body to the synapse
➡ **Axon**

56. The process of expulsion of foetus from uterus in a mammal is called
➡ **Parturition**

57. One of the many rod-like elements of compound eyes of arthropoda forming an image
➡ **Ommatidium**

58. Hormone secreted by pass nervosa of the pituitary gland. Causes strong contraction of uterine muscles and secretion of milk in mammals.
➡ **Oxytocin**

59. Peg like process of axis vertebra which projects into the ring of Atlas
➡ **Odontoid process**

60. Channels in bones around which cells and lamellae are arranged in concentric rings.
➡ **Haversian canal**

Botany

61. What are two similar halotypes called ?
➡ **Isotype**

62. Which plant of pteridophyte is called 'resurrection plant' ?
➡ ***Selaginella***

63. What is southern blotting technique ?
➡ **Recent technique used for separating DNA fragments**

64. What is the latest trend in plant disease control ?
➡ **Biological control**

65. From where does bacterium in root nodules get supply of carbohydrate ?
➡ **By the host plant**

66. When does Venus-flytrap obtain some nitrogen and minerals ?
➡ **When its leaves capture and digest insects**

67. What causes 'Stem gall of *Coriandrum*' ?
➡ ***Protomyces macrosporous* (a fungus)**

68. What are mycophages ?
➡ **Viruses attacking fungi**

69. What is photolysis of water ?
➡ **Breakdown of water molecules under the influence of light**

70. What brings about the termination of polypeptide chain ?
➡ **One of the three terminating codons, namely UAA, UAG and UGA**

71. Which plant yields latex similar to para rubber plant ?
➡ ***Parthenium argentatum***

72. What is Chargaff's rule regarding DNA bases ?
➡ **In each species the amount of A = T and the amount of G = C**

73. What is the primary acceptor of CO_2 in C_4 cycle ?
➡ **Phosphoenol pyruvic acid (PEP)**

74. What does IPM stand for ?
➡ **Integrated Pest Management**

75. How many phosphate group is contained in cyclic AMP ?
➡ **Only one phosphate**

76. Which type of RNA carries specific amino acid during protein synthesis ?
➡ ***t*-RNA**

77. What contains the bark of tree ?
➡ **Cork, Cork cambium and phloem**

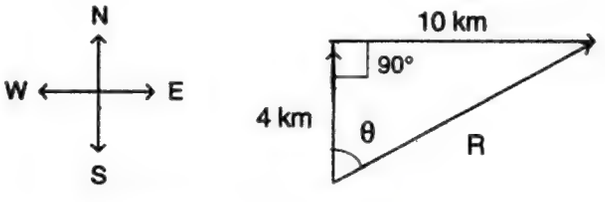
78. Who introduced hierarchy in taxonomy ?
➡ **Pranti**

79. What is regulator gene ?
➡ **Gene responsible for the synthesis of a repressor**

80. How many haploid pollen grains are formed from spore mother cell within the anther pollen sac ?
➡ **Four (due to meiotic cell division)**

HINTS

1.



Resultant R = $\sqrt{4^2 + 10^2}$

= 10·78 km

(Continued on Page 31)

Topper of Rajasthan PMT and 8th position holder in AIIMS—1999

Miss Krati Chauhan

Competition Science Vision has held an extensive interview with Miss Krati Chauhan who has been an exceptionally brilliant student. Her views are published here in original.

CSV—Congratulations for your brilliant success.

Krati—Thank you very much.

CSV—Before knowing your result what did you think about those who achieve top positions ?

Krati—I thought that all these students must have done immense hard work to achieve top position.

CSV—Achieving top position has come as surprise to you or were you confident of achieving it ?

Krati—I did all my papers well. So I was really confident that I would achieve rank among top ten position in Medical Entrance examination.

CSV—What do you think is the secret of your success ?

Krati—Channelised hard work over a period of time, perseverance and will to succeed are the reasons behind my success. Beside this I had faith in God which gave me confidence to achieve my goal.

CSV—In how many attempts did you get this success ?

Krati—I got my success in first attempt.

CSV—From where did you get the inspiration of choosing a medical career ?

Krati—I got inspiration of becoming a doctor from my father I wanted to get into a profession in which I could offer my services to help others. I used to read about how doctors save life and wanted to do something similar.

CSV—From when did you start the preparation for it ?

Krati—From class IX I started preparing for the Entrance Exams.

—Competition Science Vision is an excellent magazine. The theory, multiple choice questions, G.K. and best fifteen questions are useful and remarkable feature of the magazine. It gives relevant information in concise and brief manner. Every medical aspirant should read CSV regularly.

—Krati Chauhan

CSV—What planning did you make for preparation ? Please tell something in detail.

Krati—First of all I planned to get through with the theory of Biology, Chemistry and Physics. I started from the basics and then went on to tough topics so that I could catch with the minute details of the subject. I used to prepare a topic and then solve the multiple choice questions related with it. I practised numericals in Physics to increase my speed as time is an important factor that one has to keep in mind.

CSV—How much time did you devote daily and regularly for Physics, Chemistry, Botany and Zoology.

Krati—I used to study Physics, Chemistry daily and either Botany or Zoology along with the two. I use to devote about 8-10 hrs for studies daily and as the exams. drew nearer I increased the study hours to 14-15 hrs daily. I devoted the time among the subjects according to the topics concerned with the subject.

CSV—Out of the above four subjects, to which subject did you give more weightage and why ?

Krati—More or less I gave equal weightage to all the four subjects because to clear the competition one must be having control over all the four subjects. I gave more weightage to Physics so that I could increase my speed while solving numericals.

CSV—Did you make complete study of all topics or of some selective topics ?

Krati—I made complete study of all the topics because one can never be sure as to questions concerning to which topic will be more frequently asked in the exams.

Bio-Data

Name—*Miss Krati Chauhan*

Father's Name—*Dr. J. P. S Chauhan*

Mother's Name—*Smt. Shashi Chauhan*

Educational Qualifications—

H.S./Std.X—*88% Sophia High School, Bikaner (Raj.)1997.*

Inter/ Std. XII—*85% Maharani School, Bikaner (Raj.), 1999.*

CSV—How did you give final touches to your preparation ?

Krati—At the beginning, when I started with my preparation at that time only I used to underline important points and used to mark important questions. When I was doing revision in the end I used to go through all these underlined sentences and marked questions.

CSV—Did you prepare notes ?

Krati—I prepared notes of the topics that I found difficult in all the four subjects. I used to select a book in which the topic was presented in the simplest manner and then note it down. There notes helped me a lot during exam time.

CSV—What was your attitude for solving numerical questions. What weightage did you give them ?

Krati—While solving numericals the thing I used to keep in mind was time limit. I used to practice all sorts of numericals simple as well as tough like one which might be given to make the paper tough.

CSV—How much time is sufficient for preparing for this examination ?

Krati—I started my preparations from class IX One needs at least one year of devoted study to get through the exams. One must be very careful about dividing time according to the syllabus otherwise it creates problem at the end.

CSV—From what level of education should an aspirant begin preparing for it ?

Krati—An aspirant should start preparing for Entrance Exams from class IX.

CSV—Please mention various books in each subject and magazines on which you based your preparation.

Krati—I consulted and read following books for the preparation

Physics—1. Nutan Physics, 2. Pradeep fundamental for Physics, 3. S.C Verma.

Chemistry—Shivahare and Lavania, O.P Agarwal.

Botany—M.P. Kaushik.

Zoology—Ramesh Gupta.

CSV—Did you take coaching in your preparation ?

Krati—I joined correspondence courses of Brills education India, New Delhi, Sachdeva New P.T. College, Delhi and ALLEN Institute, Talwandi, Kota.

Personal Qualities

Hobby/Hobbies—*Listening to Music, Reading Magazines.*

Ideal Person—*Ravindra Nath Tagore.*

Strong Point—*Determination and Hard work.*

Weak Point—*Slow at work.*

CSV—What help do the science magazines render in the preparation for this examination ?

Krati—Science magazine give the students latest information about the topics. The multiple choice questions given in the magazines are examination oriented and very useful from examination point of view.

CSV—What is your opinion about our Competition Science Vision? How much helpful and useful did you find it ?

Krati—Competition Science Vision is an excellent Magazine. The theory, Multiple Choice Questions, G.K., Best Fifteen Questions are all useful and remarkable features of the magazine. Every medical aspirant should read CSV regularly. It is really very useful.

CSV—Please suggest in what way CSV can be made more useful for medical aspirants.

Krati—CSV is already very useful Magazine. By including Assertion-Reason type of questions which are useful for AIIMS it can meet its purpose more effectively.

CSV—Please mention your position in the merit list.

Krati—Rajasthan Pre-Medical Test → First Position. All India Institute of Medical Sciences, New Delhi/ Eighth Position (8^{th}). At present I am studying in AIIMS, New Delhi.

CSV—What books/ magazines/ newspaper did you read for G.K. preparations ?

Krati—For G.K preparation I depended mainly on daily news, on television and reading Times of India. I consulted CSV and India Today among the magazines.

CSV—Whom would you like to give credit for your success ?

Krati—I give credit of my success to my parents and my sisters. Without their support and encouragement I would not have achieved this target. My teachers helped me a lot by making me understood the topics. Above all it was the blessings of God and all elders which helped me to get through the exams.

CSV—What message would you like to give to our readers of CSV ?

Krati—Message is that if you are preparing for competitive exams then hard work is the only key to success. So work hard as much as you can. Prepare a plan how to complete your course and in the end a revision is a must. I would like to suggest you to keep working hard and read CSV regularly. ●●●

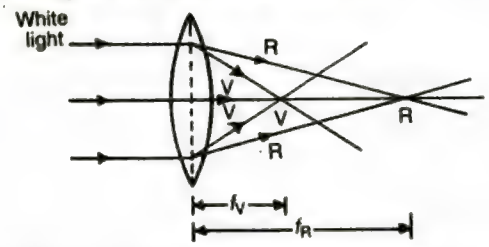
CHROMATIC ABERRATION

—Dr. R. V. S. Chauhan

1. Chromatic Aberration

The image of a white object (*i.e.*, an object illuminated by white light) formed by a lens is usually coloured and blurred. This defect of the image produced by a lens is called chromatic aberration.

Suppose parallel rays of white light fall on a lens. We know that the focal length of a lens is minimum for violet light and maximum for red light. Hence rays of violet light are focussed at shorter distance (at V) and rays of red light are focussed of larger distance (at R). Therefore, image formed by a lens becomes coloured.



- White light consists of all possible wavelengths between 3800Å and 7800Å.
- Chromatic aberration is produced by a lens because the refractive index of a material of lens and, therefore, focal length of the lens is different for different colours of light.

  Relations are as follows :

$$\mu = A + \frac{B}{\lambda^2} \qquad \text{(Cauchy's formula)}$$

and

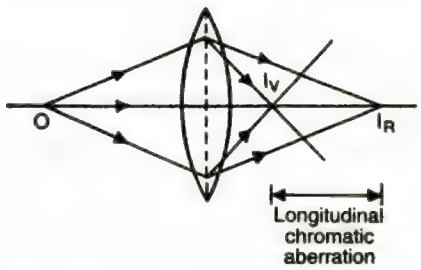
$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

(Lens maker's formula)

  where μ is refractive index of the material to lens, λ is wavelength of light, A and B are constants, f is focal length of this lens, and R_1 and R_2 are the radii of curvatures of the surface of the lens.
- Since $\mu_R < \mu_V$ so $f_R > f_V$ *i.e.* the red rays are focussed farthest and violet rays are focussed nearest to the lens. The rays of intermediate colours are focussed between V and R. If a screen is placed at V_1 the centre of image will be violet and while the outer edge will be red. At R the centre of the image will be red and outer edge violet.

Chromatic aberration is of two types—

(i) **Axial or longitudinal or linear chromatic aberration**—When a white point O is situated as the axis of a lens, then images of different colours are formed at different points along the axis. The formation of images of different colours at different positions is called axial or longitudinal aberration.



- Axial chromatic aberration
  $= I_R - I_V$,
  if the object is at finite distance from the lens
  $= f_R - f_V$,
  if the object is at infinite distance from the lens
- Axial chromatic aberration of a lens is equal to the product of its mean focal length and the dispersive power of its material.

  i.e., Axial or longitudinal aberration

$$\boxed{f_R - f_V = \omega f_y}$$

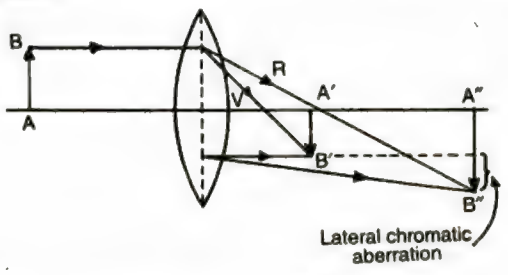
  where ω is the dispersive power of the material and f_y is the mean focal length of lens.

  Here, $\boxed{f_y = f = \sqrt{f_V f_R}}$

  and $\boxed{\omega = \frac{\delta_V - \delta_R}{\delta_y}}$ or $\boxed{\omega = \frac{\mu_V - \mu_R}{\mu_y - 1}}$
- A single lens can not remove this defect because for single lens neither $\omega = 0$ nor $f_y = 0$

  so that $f_R - f_V = \omega f_y = 0$.

(ii) **Lateral chromatic aberration**—As the different colours are focussed at different places the magnification $\left(m = \frac{f}{u+f}\right)$ produced by the lens also varies for different colours. Therefore, the images of different colours are of different sizes even if the object is of same finite size. The difference in the sizes of red and violet images is the measure of lateral chromatic aberration.



- Lateral chromatic aberration $= \frac{\omega d}{2}$

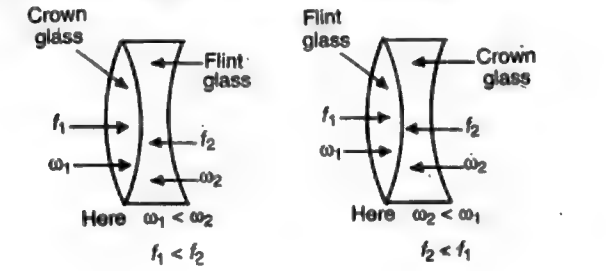
where ω is dispersive power of material of lens and d is the diameter of circle of least confusion.

- The violet image is nearest to lens and shortest in size and the red image is farthest and biggest in size.
- The situations of chromatic aberration is also true for concave lens also.

2. Achromatism

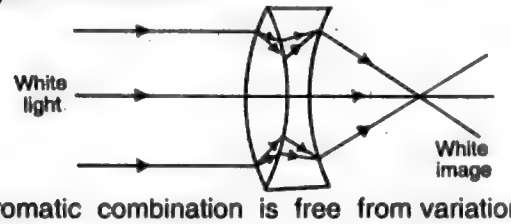
If two lenses are combined in such a way that this lens combination produces images of different colours at the same position and of the same size, then the lens combination is known as achromatic combination of lenses and this property is called achromatism.

- To remove chromatic aberration a combination of convex lens and concave lens is used. One lens is made of crown glass and other lens is made of flint glass. The focal length of this combination is equal for violet and red light *i.e.*, for this combination $(F_V = F_R)$. Hence this combination is free from chromatic aberration. It is called achromatic combination.



Achromatic convex lens **Achromatic concave lens**

- In this achromatic combination the first lens disperses white light into seven colours and second lens recombines these colours to form white light. No coloured images are obtained.



- Achromatic combination is free from variation of μ with λ.

Condition of Achromatism

We know that for this combination

$$F_V = F_R$$

But for thin lenses in contact

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\therefore \quad \frac{1}{F_V} = \frac{1}{f_V} + \frac{1}{f_{V'}}$$

{f_V and f_V' are the focal lengths for violet colours for two lenses}

$$\frac{1}{F_V} = \left(\frac{\mu_V - 1}{\mu_Y - 1}\right)\frac{1}{f_Y} + \left(\frac{\mu_{V'} - 1}{\mu_{Y'} - 1}\right)\frac{1}{f_{Y'}} \quad ...(1)$$

Similarly,

$$\frac{1}{F_R} = \left(\frac{\mu_R - 1}{\mu_Y - 1}\right)\frac{1}{f_Y} + \left(\frac{\mu_{R'} - 1}{\mu_{Y'} - 1}\right)\frac{1}{f_{Y'}} \quad ...(2)$$

According to condition

$$F_V = F_R$$

or, $$\frac{1}{F_V} - \frac{1}{F_R} = 0$$

or, $$\left(\frac{\mu_V - 1}{\mu_Y - 1}\right)\frac{1}{f_Y} + \left(\frac{\mu_{V'} - 1}{\mu_{Y'} - 1}\right)\frac{1}{f_{Y'}} -$$

$$\left(\frac{\mu_R - 1}{\mu_Y - 1}\right)\frac{1}{f_Y} - \left(\frac{\mu_{R'} - 1}{\mu_{Y'} - 1}\right)\frac{1}{f_{Y'}} = 0$$

or, $$\left(\frac{\mu_V - \mu_R}{\mu_Y - 1}\right)\frac{1}{f_Y} + \left(\frac{\mu_{V'} - \mu_R}{\mu_{Y'} - 1}\right) \times \frac{1}{f_{Y'}} = 0$$

or, $$\boxed{\frac{\omega}{f_Y} + \frac{\omega'}{f_{Y'}} = 0}$$ or $$\boxed{\omega P + \omega' P' = 0}$$

or, In general

$$\boxed{\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0}$$ or $$\boxed{\omega_1 P_1 + \omega_2 P_2 = 0}$$

{P_1 and P_2 are powers of first and second lens respectively}

or, $$\boxed{\frac{\omega_1}{f_1} = -\frac{\omega_2}{f_2}}$$ ← It is called condition of achromatism

i.e., the ratio of dispersive powers must be equal to ratio of focal lengths of two lenses.

- Here negative sign shows that two lenses must be of different nature *i.e.*, if one is convex then other is concave. Both the lenses can be neither convex nor concave.
- For achromatic combination, the lenses should be of different materials.

If $\omega_1 = \omega_2$ than $f_1 = -f_2$ and the focal length of combination $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = 0$

or, F = ∞ *i.e.* lens system will behave as a plane glass plate.

- For achromatic combination $\omega_1 P_1 = -\omega_2 P_2$

So to remove chromatic aberration, the product of power of lens and dispersive power of the lens must be equal for two lenses.

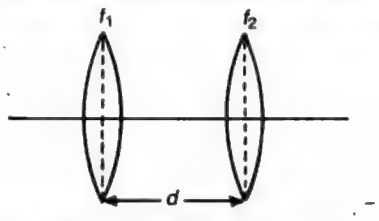
- An achromatic lens is strictly true only for the two wavelengths *e.g.*, red and violet. Other colours may be present in very small amounts. So the system is not achromatic for all colours at a time.
- In achromatic combination the lenses are cemented by canada balsam, because canada balsam is transparent and has a refractive index almost equal to the refractive index of glass.
- The achromatic doublet (combination) is used in optical instruments such as telescopes, microscopes, camera etc.

Another method of removing chromatic aberration

These days this defect is removed by taking two convex lenses of same material separated by a distance d

where $\boxed{d = \frac{f_1 + f_2}{2}}$

This combination is free from chromatic aberration.



Here if F is focal length of combination

then $\boxed{\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}}$

- This is used in making the eyepieces of telescopes and microscopes.
- Smaller the focal length of the lens, smaller is the chromatic aberration.
- In practice both the lateral and the longitudinal chromatic aberrations can not be removed for all colours. Longitudinal chromatic aberration can be removed only for two colours at a time by using lenses of suitable focal lengths and of suitable materials but lateral chromatic aberration can be removed for all colours when two lenses of same material are placed at a particular distance apart.
- The lens doublets used in telescopes are achromatic for blue and red colours while those used in camera are achromatic for violet and green colours. The reason for this is that our eye is most sensitive between blue and red colours while the photographic plates are most sensitive between violet and green colours.

TYPICAL SOLVED EXAMPLES

Example 1. Focal length of an achromatic convex lens is 24 cm. The dispersive powers of two lenses are 0·02 and 0·03. Calculate focal length of each lens.

Solution. We know that for achromatic convex lens

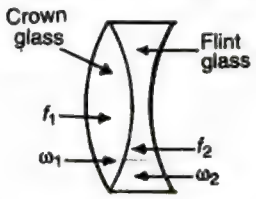
$f_1 < f_2$

and $\omega_1 < \omega_2$

Given $\omega_1 = 0{\cdot}02$

$\omega_2 = 0{\cdot}03$

and $F = 24$ cm



Achromatic convex lens

Now from achromatic condition

$$\frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2}$$

or, $$\frac{f_1}{f_2} = -\frac{\omega_1}{\omega_2} = -\frac{0{\cdot}02}{0{\cdot}03} = -\frac{2}{3}$$

$\Rightarrow$ $$f_2 = -\frac{3}{2} f_1 \qquad ...(1)$$

also $$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

or, $$\frac{1}{24} = \frac{1}{f_1} + \frac{1}{\left(-\frac{3}{2} f_1\right)} \qquad \text{from (1)}$$

$\Rightarrow$ $$\frac{1}{24} = \frac{1}{f_1} - \frac{2}{3f_1} = \frac{1}{f_1}\left(1 - \frac{2}{3}\right) = \frac{1}{3f_1}$$

$\Rightarrow$ $3f_1 = 24$

$\Rightarrow$ $f_1 = 8$ cm (*i.e.*, convex lens)

and hence $$f_2 = -\frac{3}{2} f_1 = -\frac{3}{2} \times 8$$

$= -12$ cm (*i.e.*, concave lens)

Example 2. Mean focal length of a lens is 15 cm. If the dispersive power of its glass is 0·02, then find out the axial chromatic aberration of the lens.

Solution. Axial chromatic aberration

$= \omega f_y$

$= 0{\cdot}02 \times 15 = 0{\cdot}3$ cm

Example 3. Calculate the focal length of a lens of dispersive power 0·031 which should be placed in contact with a convex lens of focal length 84 cm and dispersive power 0·021 to make the combination achromatic.

Solution. We know that for achromatic combination

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$$

Here the convex lens is made of the material of lower dispersive power

Given $f_1 = 84$ cm. $\omega_1 = 0{\cdot}021$, $\omega_2 = 0{\cdot}031$

$\therefore$ $$\frac{0{\cdot}021}{84} + \frac{0{\cdot}031}{f_2} = 0$$

$\Rightarrow$ $$\frac{0{\cdot}021}{84} = -\frac{0{\cdot}031}{f_2}$$

$\Rightarrow$ $$f_2 = -\frac{84 \times 0{\cdot}031}{0{\cdot}021}$$

$= -124$ cm

(negative sign shows that this lens is concave)

Example 4. Two lenses of different materials having dispersive powers 0·03 and 0·06 are placed in contact to produce an achromatic combination. If the power of the combination is +5 diopter, find the focal lengths of the two lenses.

Solution. Focal length of combination

$$F = \frac{100}{5} \text{ cm} = 20 \text{ cm}$$

and $$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

or, $$\frac{1}{20} = \frac{1}{f_1} + \frac{1}{f_2} \qquad ...(1)$$

also $$\frac{f_1}{f_2} = -\frac{\omega_1}{\omega_2} = -\frac{0.03}{0.06} = -\frac{1}{2}$$

$$\therefore \quad f_2 = -2f_1 \qquad ...(2)$$

putting value of f_2 from (2) in (1)

$$\frac{1}{20} = \frac{1}{f_1} - \frac{1}{2f_1} = \frac{1}{2f_1}$$

$$\Rightarrow \quad f_1 = 10 \text{ cm}$$

So, $$f_2 = -2f_1 = -20 \text{ cm}$$

Example 5. Two lenses of focal lengths 6 cm and 2 cm are placed at a certain distance apart. Calculate the distance between the lenses if they form an achromatic combination.

Solution. We know that when the lenses are separated at distance 'd' then for achromatic combination

$$d = \frac{f_1 + f_2}{2}$$

$$= \frac{6+2}{2} = \frac{8}{2}$$

$$= 4 \text{ cm.}$$

Example 6. The refractive indices of the material of a lens for violet, yellow and red colours of light are respectively 1·66, 1·64 and 1·62. The mean focal length of the lens is 10 cm. Determine the chromatic aberration of the lens between the violet and the red colours.

Solution. Let ω be the dispersive power of the material of the lens. Then the chromatic aberration between violet and red colours is given by

$$f_R - f_V = \omega \times f_Y$$

$$= \left(\frac{\mu_V - \mu_R}{\mu_Y - 1}\right) \times f_Y$$

$$= \left(\frac{1.66 - 1.62}{1.64 - 1}\right) \times 10$$

$$= 0.625 \text{ cm}$$

Example 7. An achromatic lens-doublet is formed by placing in contact a convex lens of focal length 20 cm and a concave lens of focal length 30 cm. The dispersive power of the material of the convex lens is 0·18. Determine the dispersive power of the material of the concave lens and also calculate the focal length of the lens doublet.

Solution. We know that the condition of two lenses in contact is

$$\frac{\omega_1}{f_1} = -\frac{\omega_2}{f_2}$$

$$\therefore \quad \omega_2 = -\frac{\omega_1}{f_1} \times f_2$$

where f_1 and f_2 are the mean focal lengths of the lenses and ω_1 and ω_2 are the dispersive powers.

Here $f_1 = +20$ cm, $f_2 = -30$ cm, $\omega_1 = 0.18$, $\omega_2 = ?$

$$\therefore \quad \omega_2 = -\frac{0.18}{20} \times (-30) = 0.27$$

If F is the focal length of the lens-doublet, then

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\Rightarrow \quad F = \frac{f_1 f_2}{f_1 + f_2} = \frac{(+20) \times (-30)}{+20 - 30}$$

$$= +60 \text{ cm}$$

As the focal length of the doublet is positive, it will behave as a convex lens.

Example 8. The dispersive powers of crown and flint glasses are 0·02 and 0·04 respectively. What will be the focal length of the crown-glass convex lens which forms an achromatic doublet with a flint-glass concave lens of focal length 80 cm.

Solution. Since achromatic condition is

$$\frac{f_1}{f_2} = -\frac{\omega_1}{\omega_2}$$

$$\therefore \quad f_1 = -\frac{\omega_1}{\omega_2} \times f_2$$

Here, $\omega_1 = 0.02$, $\omega_2 = 0.04$ and $f_2 = -80$ cm

$$\therefore \quad f_1 = -\frac{0.02}{0.04} \times (-80)$$

$$= +40 \text{ cm}$$

Example 9. The dispersive powers of the glasses of two lenses used in an achromatic doublet are in the ratio 4 : 3. If the focal length of one lens is 12 cm, calculate the focal length of the other lens.

Solution. The condition for achromation of two lenses in contact is

$$\frac{f_1}{f_2} = -\frac{\omega_1}{\omega_2} \qquad ...(1)$$

We know that in an achromatic (convergent) lens-doublet the dispersive powers of the material of the convex lens is less than that of the concave lens. Here, the dispersive powers are in the ratio 4 : 3. Therefore, the first lens is concave and the second is convex.

Here two cases arises :

(i) If we take the focal length of the first (concave) as 12 cm that $f_1 = -12$ cm

Then $$\frac{-12}{f_2} = -\frac{4}{3}$$

$$\Rightarrow \quad f_2 = \frac{12 \times 3}{4}$$

Then $$f_2 = 9 \text{ cm}$$

(ii) If we take the focal length of the second (convex) lens as 12 cm then $f_2 = 12$ cm and then from (1)

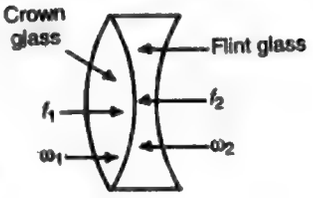
$$\frac{f_1}{12} = -\frac{4}{3}$$

$$\Rightarrow \quad f_1 = -16 \text{ cm}$$

Example 10. An achromatic convergent lens of focal length 150 cm is made by combining flint and crown glass lenses. Calculate the focal lengths of

both the lenses if the ratio of the dispersive powers of flint and crown glasses is 3 : 2.

Solution. Achromatic convergent or convex lens is shown.



and $\omega_1 = \omega_2$

$f_1 < f_2$

So according to the question

$$\frac{\omega_1}{\omega_2} = \frac{2}{3} \text{ and } F = 150 \text{ cm}$$

We know that achromatic condition is

$$\frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2} \text{ or } \frac{2}{3} = -\frac{f_1}{f_2}$$

or, $f_1 = -\frac{2}{3} f_2$ ...(1)

Also if F is focal length of the combination then

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\Rightarrow \frac{1}{150} = \frac{1}{f_1} + \frac{1}{f_2}$$

or, $\frac{1}{150} = -\frac{3}{2f_2} + \frac{1}{f_2}$

or, $\frac{1}{150} = \frac{1}{f_2}\left(1 - \frac{3}{2}\right) = -\frac{1}{2f_2}$

$\Rightarrow -2f_2 = 150$

$\Rightarrow f_2 = -75$ cm (*i.e.*, concave of flint glass)

and $f_1 = -\frac{2}{3} f_2 = -\frac{2}{3} \times (-75)$

$= +50$ cm (*i.e.*, convex of crown glass)

OBJECTIVE QUESTIONS

1. When a beam of white light parallel to the principal axis is refracted through a convex lens, then the rays converge on the principal axis. If a screen is placed at a sufficient distance from the focus-point perpendicular to the principal axis then the image on the screen will be—
   (A) A sharp white point
   (B) A sharp violet point or red point
   (C) A circular spot whose edges are red and central portion violet
   (D) A circular spot whose edges are violet and central portion red

2. Focal lengths of two lenses are f and f' and dispersive powers of their materials are ω and ω'. To form achromatic combination from these, which relation is correct ?
   (A) $\omega = \omega_o, \omega' = 2\omega_o, f' = 2f$
   (B) $\omega = \omega_o, \omega' = 2\omega_o, f' = -2f$
   (C) $\omega = \omega_o, \omega' = 2\omega_o, f' = \frac{f}{2}$
   (D) $\omega = \omega_o, \omega' = 2\omega_o, f' = -\frac{f}{2}$

3. An achromatic convergent combination of lenses is to be made by combining the lenses of flint and crown glasses. The correct choice is to use—
   (A) Both convergent lens
   (B) Both divergent lens
   (C) Convex of crown, concave of flint
   (D) Concave of crown, convex of flint

4. An achromatic combination of lenses is used to produce—
   (A) Coloured image
   (B) Image in black and white
   (C) Highly enlarged image
   (D) Image free from colours

5. A convex lens has a mean focal length of 25 cm and the dispersive power of the material of the lens is 0·04. The longitudinal chromatic aberration for an object placed at infinity is—
   (A) 0·5 cm (B) 1·0 cm
   (C) 0·0016 cm (D) 2·5 cm

6. A thin convex lens has focal lengths 50·5 cm and 49·5 cm for red and violet colours respectively. The dispersive power of the lens material is—
   (A) 0·01 (B) 0·02
   (C) 0·04 (D) 0·20

7. An achromatic doublet of resultant focal length 100 cm is made using a convex lens of crown glass (ω = 0·02) and concave lens of flint glass (ω = 0·03). The focal lengths of lenses are—
   (A) Convex f = 75 cm, concave f = 25 cm
   (B) Convex f = 50 cm, concave f = 75 cm
   (C) Convex f = 33·3 cm, concave f = 50 cm
   (D) Convex f = 50 cm, concave f = 33·3 cm

8. Chromatic aberration in a lens is caused by—
   (A) Reflection (B) Interference
   (C) Diffraction (D) Dispersion

9. An achromatic convergent doublet of two lenses in contact has a power of + 2D. The convex lens has a power +5D. What is the ratio of the dispersive powers of the convergent and divergent lenses ?
   (A) 2 : 5 (B) 3 : 5
   (C) 5 : 2 (D) 5 : 3

10. A double convex lens is made of glass which has its refractive index of 1·55 for violet rays and 1·50 for red rays. If the focal length for violet rays is 20 cm, then the focal length for red rays will be—
    (A) 9 cm (B) 18 cm
    (C) 20 cm (D) 22 cm

11. The focal lengths of a convex lens for blue and red colours of light are f_b and f_r respectively and those of concave lens are F_b and F_r. Then—
    (A) $f_b > f_r$ and $F_b < F_r$
    (B) $f_b < f_r$ and $F_b > F_r$
    (C) $f_b > f_r$ and $F_b > F_r$
    (D) $f_b < f_r$ and $F_b < F_r$

12. A convex lens, a glass slab, a glass prism and a spherical solid ball have been prepared from the same optically transparent material. Dispersive power will be possessed by—
(A) The glass slab and the prism
(B) The lens and the solid ball
(C) The prism only
(D) All the four

13. What causes chromatic aberration ?
(A) Nonparaxial rays
(B) Paraxial rays
(C) Variation of focal length with colour
(D) Difference in radii of curvature of the bounding surfaces of the lens

14. To obtain an achromatic combination using the lenses of same material, the two lenses should be—
(A) Put in contact
(B) Separated from each other
(C) Convex
(D) One convex and other concave

15. A convex lens forms real image of an extended object. The image is coloured due to chromatic aberration. What will be the colour of the image of least size ?
(A) Red (B) Yellow
(C) Green (D) Blue

16. An equiconvex lens of crown glass and an equiconcave lens of flint glass make an achromatic system. The radius of curvature of convex lens is 0·54 m. If the focal length of the combination for the mean colour is 1·50 and the refractive indices for the crown glass are $\mu_R = 1{\cdot}53$ and $\mu_V = 1{\cdot}55$, then the dispersive power of the flint glass will be—
(A) 0·055 (B) 0·037
(C) 0·027 (D) 0·015

17. A paralled beam of white light falls on a convex lens. Images of blue, yellow and red light are formed on other side of the lens at a distance of 20 cm, 20·5 cm and 21·4 cm respectively. The dispersive power of the material of the lens will be—
(A) $\frac{619}{1000}$ (B) $\frac{9}{200}$
(C) $\frac{14}{205}$ (D) $\frac{5}{214}$

18. The dispersive powers of the materials of the two lenses are in the ratio 4 : 3. If the achromatic combination of these two lenses in contact is a convex lens of focal length 60 cm, then the focal length of the component lenses are—
(A) – 20 cm and 25 cm
(B) 20 cm and – 25 cm
(C) – 15 cm and – 20 cm
(D) 15 cm and – 20 cm

19. An achromatic combination consists of a convex lens and a concave lens kept in contact. ω_1 and ω_2 are dispersive powers of material of these lenses respectively and f_1 and f_2 are their focal lengths respectively. To form an achromatic concave lens—
(A) $\omega_1 > \omega_2$, $f_1 > f_2$
(B) $\omega_1 > \omega_2$, $f_1 < f_2$
(C) $\omega_1 < \omega_2$, $f_1 > f_2$
(D) $\omega_1 < \omega_2$, $f_1 < f_2$

20. Chromatic aberration of lens can be corrected by—
(A) Providing different suitable curvatures to its surfaces
(B) Proper polishing of its two surfaces
(C) Suitably combining it with another lens
(D) Reducing its aperture

21. To remove chromatic aberration the combination of lenses should be such that—
(A) $F_R + F_R = 0$
(B) $F_R > F_V$
(C) $F_R < F_V$
(D) $F_R - F_V = 0$

22. If a divergent lens of focal length 50 cm is put in contact with a convergent lens of focal length 70 cm, the doublet will be—
(A) Convergent of f = 175/6 cm
(B) Convergent of f = 175 cm
(C) Divergent of f = 175/6 cm
(D) Divergent of f = 175 cm

23. Two lenses in contact form an achromatic lens. Their focal lengths are in the ratio of 2 : 3. Their dispersive powers must be in the ratio of—
(A) 1 : 3 (B) 2 : 3
(C) 3 : 2 (D) 3 : 1

24. Lateral chromatic aberration is the formation of—
(A) Blurred images
(B) Distorted images
(C) Images of different colours in different sizes
(D) Images of different colours at different positions

25. Two convex lenses of same focal length are made of crown and flint glass respectively. The axial chromatic aberration is—
(A) Equal for the two lenses
(B) Greater for the crown glass lens
(C) Greater for the flint glass lens
(D) Sometimes greater for crown glass lens and sometimes for flint glass lens

ANSWERS

1. (D) 2. (B) 3. (C) 4. (D) 5. (B)
6. (B) 7. (C) 8. (D) 9. (B) 10. (D)
11. (D) 12. (D) 13. (C) 14. (B) 15. (D)
16. (A) 17. (C) 18. (D) 19. (A) 20. (C)
21. (D) 22. (D) 23. (B) 24. (C) 25. (C)

HINTS

1. Due to chromatic aberration the images of different colours will be at different positions. On placing screen at a sufficient distance from focus, we will get image on the screen as a circular spot whose edges are violet and central portion red because focal length for violet colour is less than for red colour.

2. We know that for achromatic combination

$$\frac{\omega}{\omega'} = -\frac{f}{f'}$$

This relation is correct for (B) as

$$\frac{\omega}{\omega'} = \frac{\omega_o}{2\omega_o} = \frac{1}{2}$$

and $$-\frac{f}{f'} = -\frac{f}{(-2f)} = \frac{1}{2}$$

3. Since combination is to behave as convex lens, the focal length of convex less should be less and should, therefore, be made of material of less dispersive power *i.e.*, of crown glass whose refractive power is less than that of flint glass.

5. Longitudinal chromatic aberration

$$= f_R - f_V = \omega f_Y$$
$$= 0{\cdot}04 \times 25$$
$$= 1 \text{ cm}$$

6. We know that

$$f_R - f_V = \omega f_Y$$
$$\therefore \quad \omega = \frac{f_R - f_V}{f_Y}$$

Here f_Y is the mean focal length

$$= \frac{50{\cdot}5 + 49{\cdot}5}{2} = 50$$
$$\therefore \quad \omega = \frac{50{\cdot}5 - 49{\cdot}5}{50} = \frac{1}{50} = 0{\cdot}02$$

7. Given $F = 100$ cm

For convex lens $\omega = 0{\cdot}02$ and

For concave lens $\omega' = 0{\cdot}03$

$$\therefore \quad \frac{f}{f'} = -\frac{\omega}{\omega'} = -\frac{0{\cdot}02}{0{\cdot}03} = -\frac{2}{3}$$
$$\Rightarrow \quad \frac{1}{f'} = -\frac{2}{3f}$$

Also $$\frac{1}{F} = \frac{1}{f} + \frac{1}{f'}$$
$$\Rightarrow \quad \frac{1}{100} = \frac{1}{f} - \frac{2}{3f} = \frac{1}{3f}$$
$$\Rightarrow \quad 3f = 100$$
$$\Rightarrow \quad F = 33{\cdot}3 \text{ cm}$$

and $$f' = -\frac{3}{2}f = -\frac{3}{2} \times 33{\cdot}3$$
$$= -50 \text{ cm}$$

9. We know that power of the combination

$$P_C = P_1 + P_2$$

Here $P_C = +2D$, $P_1 = +5D$

$$\therefore \quad 2 = 5 + P_2$$
$$P_2 = -3D$$

Power of concave lens $= -3D = P_2$

Power of convex lens $= +5D = P_1$

and for achromatic combination

$$P_1\omega_1 + P_2\omega_2 = 0$$
$$\Rightarrow \quad \frac{\omega_1}{\omega_2} = -\frac{P_2}{P_1}$$
$$\Rightarrow \quad \frac{\omega_1}{\omega_2} = -\frac{(-3)}{5} = \frac{3}{5}$$
$$\therefore \quad \omega_1 : \omega_2 = 3 : 5$$

10. For lens

$$\frac{1}{f_R} = (\mu_R - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \qquad \ldots(1)$$

and $$\frac{1}{f_V} = (\mu_V - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \qquad \ldots(2)$$

Dividing (2) by (1)

$$\frac{f_R}{f_V} = \frac{\mu_V - 1}{\mu_R - 1} = \frac{1{\cdot}55 - 1}{1{\cdot}50 - 1} = \frac{0{\cdot}55}{0{\cdot}50}$$
$$f_V = 20 \text{ cm}$$
$$\therefore \quad \frac{f_R}{20} = \frac{55}{50} = \frac{11}{10}$$
$$\Rightarrow \quad f_R = 22 \text{ cm}$$

15. Out of all the four colours (red, yellow, blue and green) blue colour has least focal length and hence image of blue colour is of least size.

16. We know that the condition for achromatism of two lenses in contact is

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0 \qquad \ldots(1)$$

For crown glass

$$\omega_1 = \frac{\mu_V - \mu_R}{\frac{\mu_V + \mu_R}{2} - 1}$$
$$= \frac{1{\cdot}55 - 1{\cdot}53}{\frac{1{\cdot}55 + 1{\cdot}53}{2} - 1}$$
$$= \frac{1{\cdot}55 - 1{\cdot}53}{1{\cdot}54 - 1} = 0{\cdot}037$$

and $$\frac{1}{f_1} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\left\{\mu = \frac{\mu_V + \mu_R}{2} = \frac{1{\cdot}55 + 1{\cdot}53}{2} = 1{\cdot}54\right\}$$

$$= (1{\cdot}54 - 1)\left(\frac{1}{0{\cdot}54} + \frac{1}{0{\cdot}54}\right)$$
$$= 2$$

If F be the focal length of the combination, then

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$
$$\therefore \quad \frac{1}{f_2} = \frac{1}{F} - \frac{1}{f_1}$$

or, $$\frac{1}{f_2} = \frac{1}{1{\cdot}5} - 2 = -\frac{4}{3}$$

where f_2 is the focal length of flint glass

Now from equation (1)

$$0{\cdot}037 \times 2 + \omega_2\left(-\frac{4}{3}\right) = 0$$
$$\Rightarrow \quad \omega_2 = \frac{0{\cdot}037 \times 2 \times 3}{4}$$
$$= 0{\cdot}055$$

17. We know that when parallel rays fall on a convex lens, they converge at the focal point. So according to the question

$$f_b = 20 \text{ cm}$$
$$f_y = 20{\cdot}5 \text{ cm and } f_R = 2{\cdot}14 \text{ cm}$$

also the dispersive power

$$\omega = \frac{f_R - f_b}{f_y}$$
$$= \frac{21{\cdot}4 - 20}{20{\cdot}5} = \frac{1{\cdot}4}{20{\cdot}5}$$
$$= \frac{14}{205}$$

18. When lenses are in contact then we know that

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

Here $F = 60$ cm

$$\therefore \quad \frac{1}{60} = \frac{1}{f_1} + \frac{1}{f_2} \qquad \ldots(1)$$

Also for achromatic combination

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$$

or, $$\frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2}$$

but $$\frac{\omega_1}{\omega_2} = \frac{3}{4}$$

$$\therefore \quad \frac{3}{4} = -\frac{f_1}{f_2}$$

or, $$f_2 = -\frac{4}{3} f_1 \qquad \ldots(2)$$

From (1) and (2)

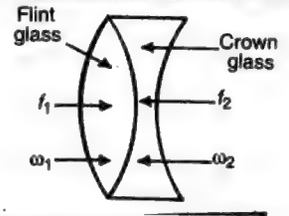
$$\frac{1}{60} = \frac{1}{f_1} - \frac{3}{4f_1}$$

On solving we get

$$f_1 = +15 \text{ cm}$$

and $$f_2 = -20$$

19. For achromatic concave lens



(Achromatic concave lens)

$\omega_1 > \omega_2$ and $f_1 > f_2$

22. When lenses are in contact then

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

Given $f_1 = -50$ cm and $f_2 = 70$ cm

So $$\frac{1}{f} = \frac{1}{-50} + \frac{1}{70}$$
$$= \frac{-70 + 50}{50 \times 70} = -\frac{20}{35 \times 100}$$
$$= -\frac{1}{175}$$

$$\Rightarrow \quad f = -175 \text{ cm}$$

(divergent since f is negative)

23. $\because$ $$\frac{\omega}{\omega'} = -\frac{f}{f'} = \frac{2}{3}$$

25. Since axial chromatic aberration

$$= \omega f_y$$

Here focal lengths for both lenses are same. But we know that flint glass has move dispersive power than crown glass, therefore, axial chromatic aberration is greater for the flint glass lens.

●●●

(Continued from Page 21)

$$\tan\theta = \frac{10}{4} = 2{\cdot}5$$

$$\Rightarrow \quad \theta = 68{\cdot}2° \text{ East of North}$$

4. Initial angular speed

$$\omega_i = 0$$

Final angular speed

$$\omega_f = \frac{1200}{60} \times 2\pi$$
$$= 40\,\pi \text{ rad/sec}$$

$\therefore$ Angular acceleration

$$= \frac{\omega_f - \omega_i}{20} = \frac{40\,\pi}{20}$$
$$= 2\pi \text{ rad/sec}^2$$

8. $$\text{Shearing stress} = \frac{\text{Tangential force}}{\text{Area of face}}$$
$$= \frac{900 \times 10^3 \times 980}{10^2}$$
$$= 8{\cdot}82 \times 10^6 \text{ dyne/cm}^2$$

9. Let V be the volume of liquid held by bottle.

$$V = \frac{\text{Mass of milk}}{\text{Density of milk}}$$
$$= \frac{247{\cdot}2}{1{\cdot}03}$$
$$= 240 \text{ c.c.}$$

$\therefore$ Required mass of glycerine

$$= 1{\cdot}26 \times 240$$
$$= 302{\cdot}4 \text{ gm}$$

10. $$\eta = \frac{F \cdot l}{A \cdot v}$$
$$[\eta] = \frac{[MLT^{-2}][L]}{[L^2][LT^{-1}]}$$
$$= [ML^{-1}T^{-1}]$$

16. $$\text{R. H.} = \frac{\text{Mass of water vapour actually present in a certain volume of air}}{\text{Mass of water vapour required to saturate the same volume at the same temperature}}$$
$$= \frac{1{\cdot}5}{3{\cdot}75} \times 100$$
$$= 40\%$$

●●●

MEASURING INSTRUMENTS

—Er. D. K. Gupta

One basic measuring instrument is 'galvanometer', whose pointer shows a deflection when current passes through it. Using a galvanometer one can easily construct a device for measuring current, potential difference or resistance, ammeter, voltmeter and ohmmeter respectively. For accurate measurement of potential difference or e.m.f. one uses a potentiometer whereas resistances are accurately measured using a Wheatstone bridge. All these instruments are discussed here one by one in brief.

(A) Galvanometers :

(a) It is an instrument used to detect the presence of current upto 10^{-9} A through it.

(b) The current is the measure of the deflection of the coil due to torque produced by a magnetic field.

(c) Galvanometers are mainly of two types :

(i) Moving coil galvanometer.

(ii) Moving magnet galvanometer.

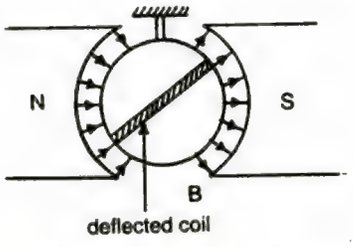
(d) Moving coil galvanometers are of two types :

(i) Suspended coil galvanometer.

(ii) Pivoted coil galvanometer.

(e) In moving coil galvanometer the coil is movable and magnet is stationary whereas magnet is movable and coil is stationary in moving magnet galvanometer.

Moving coil galvanometer—(a) **Principle**—In this galvanometer, a coil is free to rotate in a radial magnetic field produced by a permanent magnet. When the current is passed through the coil, a couple acts on it due to the magnetic field. This is opposed by the torsional couple produced in the suspension wire (in the case of suspended coil galvanometer) or in the springs (in the case of a pivoted coil galvanometer) and the coil is deflected by angle θ, when the two couples balance each other.



(b) **Construction**—A rectangular coil is suspended between the pole pieces of a cylindrical magnet with the help of a fine phosphor bronze fibre.

(c) In state of equilibrium of coil,

deflecting torque = restoring torque

$$NIAB \sin\theta_0 = C\theta$$

where θ_0 is the angle which the normal to the plane of the coil makes with the direction of the field

For radial magnetic field,

$$\theta_0 = 90°$$

$$\therefore \quad NIAB = C\theta$$

$$\therefore \quad I = \left(\frac{C}{NAB}\right)\theta$$

$$= K\theta$$

where K is the galvanometer constant which depends on the construction of the galvanometer.

(d) From above, we have, $\boxed{I \propto \theta}$

Therefore the deflection produced in the coil is directly proportional to the current flowing in the coil.

(e) For Lamp and Scale arrangement

$$\theta = \frac{d}{2D}$$

where d = displacement of light spot

D = distance of scale from galvanometer

when D = 1 metre

$$\boxed{\theta \propto d}$$

(f) Sensitivity of galvanometer is defined as the deflection of galvanometer coil per unit current.

Sensitivity of galvanometer

$$\boxed{S_I = \frac{\theta}{I}}$$

(g) The galvanometer which gives more deflection for a small current is more sensitive. To increase sensitivity the values of N, A, B must be large and the value of C must be small.

(h) The reciprocal of current sensitivity is defined as the figure of merit of galvanometer (K).

$$\boxed{K = \frac{1}{S_I} = \frac{I}{\theta}}$$

Thus the current required for unit deflection in galvanometer is known as figure of merit.

(i) The deflection of galvanometer coil per unit voltage is defined as voltage sensitivity of galvanometer.

Voltage sensitivity of galvanometer

$$\boxed{S_V = \frac{\theta}{V}}$$

or, $$S_V = \frac{\theta}{IG} = \frac{NIAB}{IG}$$

or, $$\boxed{S_V = \frac{NAB}{G}}$$

where G = resistance of galvanometer coil.

Note : A galvanometer is a low resistance instrument. Even when a small current is passed through the galvanometer, it produces full scale deflection. If a large current is passed, the galvanometer may be damaged because of the following two reasons :

(i) The large current will cause the coil of the galvanometer to deflect through a large angle and the pointer of the galvanometer in an attempt to go out of scale, may break.

(ii) The large current will produce a large amount of heat in the coil of the galvanometer which may also damage the galvanometer.

(B) Tangent Galvanometer :

(a) In the tangent galvanometer, the magnetic field produced by a current carrying circular coil becomes perpendicular to the direction of earth's magnetic field, when the plane of the coil is vertical and lie in the magnetic meridian. Under the combined effect of these two mutually perpendicular fields, a small magnetic needle pivoted at the centre of the coil is made to deflect.

(b) If the needle deflects through an angle θ, then according to tangent law, the current in the coil is given by

$$\frac{2\pi NI}{10r} = H \tan\theta$$

or, $$I = \left(\frac{10\,rH}{2\pi N}\right)\tan\theta$$

$$= K \tan\theta$$

or, $$\boxed{I \propto \tan\theta}$$

where, I = current in the coil

r = radius of the coil

H = horizontal intensity of the earth's magnetic field

N = number of turns in the coil

(c) For a given galvanometer,

$$\frac{10rH}{2\pi N} = K$$

where K is a constant, called the reduction factor.

(d) The reduction factor of a tangent galvanometer is equal to the current which deflects its needle by 45°.

(C) Ammeter :

(a) Ammeter is an instrument used for measuring current in an electrical circuit.

(b) An ammeter is always connected in the circuit in series.

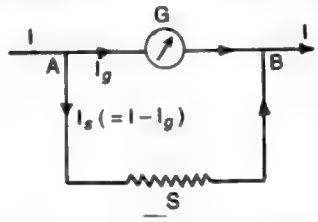
(c) Since the ammeter is essentially a galvanometer, its coil has some resistance, so on connecting it in series, the resistance of the circuit increases and, therefore, the current in it somewhat decreases. Thus the current measured by an ammeter is less than the actual current to be measured.

(d) An ammeter should have as small a resistance as possible so that on connecting it in the circuit, the current to be measured may not change appreciably.

(e) An ideal ammeter should have zero resistance but it is not possible.

(f) **Conversion of a Galvanometer into an ammeter**—(i) An ammeter is in fact a shunted galvanometer.

(ii) A galvanometer may be converted into an ammeter of any required range by connecting a suitable resistance shunt S in parallel with its coil.



$$V_A - V_B = I_g G = (I - I_g)S$$

$$\Rightarrow \quad \boxed{I_g = I\frac{S}{G+S}}$$

This reduces to

$$\boxed{S = \frac{I_g}{I - I_g} \times G}$$

Since $I_S = I - I_g$

$$\boxed{\therefore I_S = I\,\frac{G}{G+S}}$$

Also, $$\boxed{S = \frac{G}{(n-1)}}$$

where I_g = full scale deflection in the galvanometer

$I_s = I - I_g$ current in the shunt

G = Galvanometer resistance

S = Shunt resistance

and $n = \dfrac{\text{New Range}}{\text{Old Range}} = \dfrac{I}{I_g}$

Shunt

The small resistance connected in parallel to galvanometer coil, in order to control current flowing through the galvanometer, is known as shunt.

Advantages of shunt :

(i) The combined resistance of a shunted galvanometer becomes quite low so that when it is used in series with a circuit it does not disturb the current to be measured.

(ii) It protects the galvanometer coil from burning.

(iii) Any galvanometer can be converted into ammeter of desired range with the help of a shunt.

(iv) The range of an ammeter can be changed by using shunt resistances of different values.

Disadvantage of shunt :

Shunt resistance decreases the sensitivity of the galvanometer.

(D) Voltmeter :

(a) A voltmeter is used to measure the potential difference between two points in an electric circuit.

(b) It is always connected in parallel with resistance across which potential difference is to be measured.

(c) Voltmeter is also essentially a moving coil galvanometer with a high resistance in series.

(d) When a voltmeter is connected across two points to measure the potential difference, it draws some current for its own deflection. This lowers the potential difference to be measured. Thus the potential difference measured by a voltmeter is less the actual potential difference to be measured.

(e) A voltmeter should have as large a resistance as possible so that on connecting it across the given points, it may not draw appreciable current. Hence, the potential difference across the points may not change appreciably.

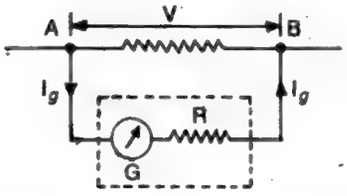
(f) An ideal voltmeter should have infinite resistance *i.e.*, it should draw no current from source of potential difference. (null deflection method). (Potentiometer achieves this).

(g) A voltmeter having a higher resistance is a better one for better accuracy.

(h) **Conversion of Galvanometer into a voltmeter**—(i) To convert a galvanometer into a voltmeter, a suitable high resistance has to be connected in series with it.

(ii) In fact it measures small current and is graduated in terms of potential difference (product of current and resistance).

(iii)



The value of the resistance R required to be, connected in the series of the galvanometer to convert it into a voltmeter of range V is given by

$$I_g = \frac{V}{R+G}$$

$$\Rightarrow \quad \boxed{R = \frac{V}{I_g} - G}$$

where G = resistance of galvanometer
I_g = current which produces full scale deflection in the galvanometer

(iv) If we want to increase the range of a voltmeter from V_1 to V_2, we should connect a resistance of

$$R = G(n-1) \text{ in series}$$

where,
$$n = \frac{\text{New Range}}{\text{Old Range}} = \frac{V_2}{V_1}$$

Points to Remember

(a) By connecting a small resistance $\left(R_S = \frac{G}{n-1}\right)$ in parallel we can :

(i) Convert galvanometer into ammeter.

(ii) Increase the range of an ammeter.

(iii) Convert voltmeter into an ammeter.

(b) By connecting a high resistance

$R = G(n-1)$ in series we can

(i) Convert galvanometer into voltmeter.

(ii) Increase the range of a voltmeter.

(iii) Convert an ammeter into a voltmeter.

Difference between voltmeter and ammeter :

S. No.	Voltmeter	Ammeter
1.	It measures potential difference.	It measures the strength of current.
2.	It is connected in parallel in a circuit.	It is connected in series in a circuit.
3.	The resistance of an ideal voltmeter is infinity.	The resistance of an ideal ammeter is zero.
4.	In conversion from galvanometer, a series resistance of high value is connected in series with the coil.	In conversion from galvanometer, a low resistance (shunt) is connected in parallel to the coil.

(E) Potentiometer :

(a) A potentiometer is an arrangement which measures potential difference accurately. It can also be adapted to measure current and resistance.

(b) **Principle**—The potentiometer is based upon the principle that when a constant current is passed through a wire of uniform area of cross-section, the potential drop across any portion of wire is directly proportional to the length of that portion.

(c) **Potential gradient**—The fall of potential per unit length of potentiometer wire is defined as pontential gradient (x)

$$x = \frac{V}{l}$$

where V is the potential difference across the potentiometer wire

x depends upon—

(i) The specific resistance of the material of the potentiometer (K).

(ii) The resistance per unit length of the potentiometer wire P.

(iii) The radius of potentiometer wire (r).

(iv) The current flowing through the potentiometer wire (I).

(d) **Sensitivity of potentiometer :**

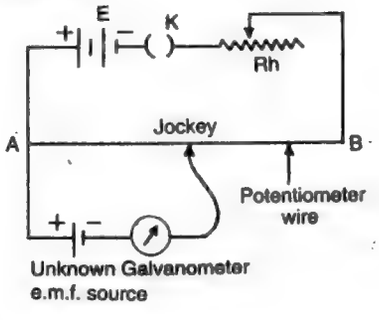
(i) The sensitivity of potentiometer is inversely proportional to the potential gradient.

(ii) A potentiometer is said to be more sensitive if it measures a small potential difference more accurately.

(iii) In order to increase the sensitivity, the length of potentiometer wire will have to be increased so that the length may be measured more accurately.

(e) The process of determining potential gradient experimently is known as standardization of potentiometer.

(f) **Circuit diagram :**



(g) **Applications of potentiometer :**

It is used to—

(i) Measure potential difference.

(ii) Determine the internal resistance of a cell.

(iii) Measure current.

(iv) Compare e.m.fs of two cells.

(v) Calibrate ammeter and voltmeter.

(vi) Compare two small resistance.

(vii) Determine thermo e.m.f.

(h) Internal resistance of a cell can be determined by using the relation.

$$r = \left(\frac{l_1 - l_2}{l_2}\right) R$$

where, R = resistance used from the resistance box.

l_1 = balancing length corresponding to cell in open circuit.

l_2 = balancing length corresponding to cell in closed circuit

(i) To compare e.m.f.'s of two cells, we can use the relation—

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

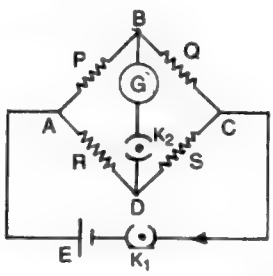
Difference between Potentiometer and Voltmeter

S. No.	Voltmeter	Potentiometer
1.	The potential difference measured by voltmefer is less than the actual potential difference.	The potential difference measured by potentiometer is equal to the actual potential difference.
2.	It is a low sensitivity instrument.	Its sensitivity is high.
3.	It draws some current from the source of e.m.f.	It does not draw any current from the source of e.m.f. under test
4.	It is based on deflection method.	It is based on zero deflection method.

(F) Wheatstone Bridge :

(i) It is an arrangements for measuring the resistance of a conductor.

(ii) **Circuit diagram**



(iii) **Principle**—The resistances, P, Q, R and S are so adjusted that when keys K_1 and K_2 are pressed there is no deflection in the galvanometer, then

$$\frac{P}{Q} = \frac{R}{S}$$

If the ratio of the resistances P and Q, and the resistance R are known, then the unknown resistance can be calculated.

(iv) At balance, no current flows through G, therefore, the potential difference across BD is zero and so potential difference across AB

= potential difference across AD

(v) At balance, current through resistance P

= current through resistance Q

and, current through resistance R

= current through resistance S

(vi) The sensitivity of the bridge is maximum when all the four resistances are of same order.

(vii) While performing experiment with Wheatstone bridge the cell key K_1 should be pressed first and then galvanometer key K_2 otherwise a momentary deflection in galvanometer is produced even in balanced bridge due to induced e.m.fs in various resistance coils as initially the current is changing from 0 to I. While leaving the keys this order should be reversed.

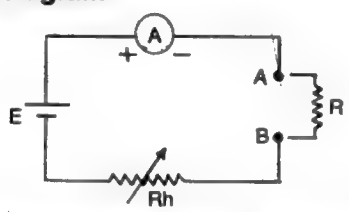
(viii) Post office box, meter bridge and Carey Foster bridge are instruments based on the principle of Wheatstone bridge and are used to measure unknown resistance or specific resistance.

Note—Wheatstone bridge is not suitable for the measurement of very low resistances or very high resistances of order of mega ohms. Very low resistances are determined with the help of 'Kelvin's double bridge' while very high resistances by 'Leakage method'.

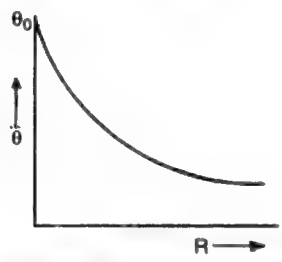
(G) Ohm-meter :

(i) It is an instrument designed to measure resistance.

(ii) **Circuit diagram**



(iii) **Principle**—The terminals A and B are first short circuited and the resistance Rh is adjusted till the ammeter shows full scale deflection. The full scale reading corresponds to zero external resistance. Now connecting a resistance box between points A and B, ammeter deflection θ is noted for different values of R and a graph is plotted between θ and R.



The graph is called calibration curve.

Now replacing the resistance box by unknown resistance R, θ' is noted and from the calibration curve value of R corresponding to deflection θ' is determined.

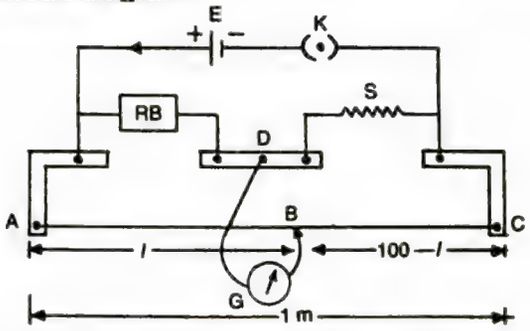
(H) Post Office Box :

This instrument used to determine the breakage in telegraph line in post and telegraph office is known as Post Office box.

(I) Meter Bridge :

(i) It is used to determine the resistance of a conducting wire.

(ii) **Circuit diagram—**



(iii) **Principle**—The meter bridge, a form of the Wheat-stone bridge, consists of points A, B, C and D corresponding to the four corners of the Wheatstone bridge where a galvanometer is connected across B and D. Here point B is the point for no deflection in the galvanometer.

The meter bridge is said to be in balance position when,

$$\frac{R}{S} = \frac{l}{(100 - l)}$$

or, unknown resistance

$$\boxed{S = \frac{(100 - l)}{l} \times R}$$

(iv) Resistances ranging from 1Ω to 10^3 Ω can be measured with the help of meter bridge.

TYPICAL SOLVED EXAMPLES

Example 1. A galvanometer of resistance 20Ω gives full scale deflection with a current of 2mA. What size resistance should be connected in parallel so that it may measure 2 amp on full scale deflection ?

(A) 0·04 Ω (B) 0·4 Ω
(C) 0·02 Ω (D) 0·2 Ω

Solution :

$$I_g = I\frac{S}{G + S}$$

$$\frac{2}{1000} = 2\frac{S}{20 + S}$$

$$\Rightarrow \quad S = \frac{20}{999} = 0{\cdot}02\ \Omega$$

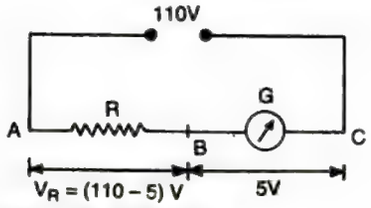
Hence, the answer (C) is correct.

Example 2. A 100 V voltmeter having an internal resistance of 20 kΩ, when connected in series with a large resistance R across a 110 V line reads 5V. The magnitude of R is :

(A) 210 kΩ (B) 315 kΩ
(C) 420 kΩ (D) 440 kΩ

Solution : Resistance of voltmeter

$$G = 20\ k\Omega$$
$$= 20 \times 10^3\ \Omega$$



Current through voltmeter

$$= \frac{110}{R + 20 \times 10^3}$$

Potential drop across R, V_R

$$= \frac{110}{R + 20 \times 10^3} \times R$$

Now, since, $V_R + 5 = 110$

or, $V_R = 105$

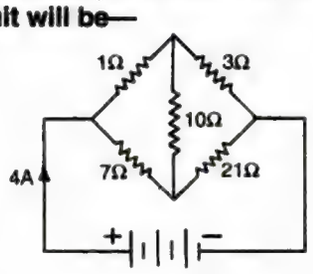
$$\therefore \quad \frac{110\,R}{R + 20 \times 10^3} = 105$$

or, $110\,R = 105R + 105 \times 20 \times 10^3$

$$\Rightarrow \quad R = \frac{105 \times 20 \times 10^3}{5}$$
$$= 420\ k\Omega$$

Hence, the answer (C) is correct.

Example 3. In the circuit shown in figure below, the current drawn from the battery is 4A. If 10Ω resistor is replaced by 20Ω resistor, the current drawn from the circuit will be—



(A) 1A (B) 2A
(C) 4A (D) 8A

Solution : Since the bridge is balanced, there is no current in the arm containing 10Ω resistance. So, replacing it with 20Ω resistance will make no difference.

Thus answer (C) is correct.

Example 4. In a potentiometer of 10 wires, the balance point is obtained on the 6th wire. To shift the balance point to 8th wire, we should—

(A) Increase resistance in the main circuit
(B) Decrease resistance in the main circuit.
(C) Increase resistance in series with the cell whose e.m.f. is to be measured
(D) Decrease resistance in series with the cell whose e.m.f. is to be measured

Solution : When the resistance of the main circuit is increased the current through the wire decreases. So, the potential drop which earlier existed on the 6th wire, may now be found on the 8th wire.

Answer (A) is correct.

Example 5. A voltmeter of range 0 to 100 mV is calibrated with the help of a potentiometer having 4m wire. It gives full deflection, when connected across the two ends of the wire. If it reads 35mV when connected across 1·41m of the wire, what is the error in the reading ?

(A) 1 mV (B) 0·5 mV
(C) 0·25 mV. (D) No error

Solution : Potential gradient

$$= \frac{100 \times 10^{-3}}{4}$$

$$= 25 \times 10^{-3} \text{ V/m}$$

Reading across 1·41 m wire

$$= 1{\cdot}41 \times 25 \times 10^{-3} \text{ V}$$

$$= 35{\cdot}25 \text{ mV}$$

Hence, error in the reading

$$= 35{\cdot}25 - 35{\cdot}00$$

$$= 0{\cdot}25 \text{ mV}$$

Answer (C) is correct.

OBJECTIVE QUESTIONS

1. In a moving coil galvanometer the deflection of the coil is related to the electric current by the relation—
   (A) $I \propto \tan\theta$ (B) $I \propto \theta$
   (C) $I \propto \theta^2$ (D) $I \propto \sqrt{\theta}$
   (CPMT)

2. A galvanometer of resistance 95 ohm shunted by a resistance of 5 ohm gives a deflection of 50 divisions when joined in series with a resistance of 20k ohm and a 2·0 V accumulator. The current sensitivity of the galvanometer, in division per μA is—
   (A) (1/2) (B) 1
   (C) 5 (D) 10

3. To use a moving coil galvanometer as an ammeter one must connect—
   (A) Low resistance in series with coil
   (B) A high resistance in parallel with the coil
   (C) A high resistance in series with the coil
   (D) A low resistance in parallel with the coil.
   (CPMT)

4. An ammeter can be converted into a voltmeter by connecting—
   (A) A low resistance in series
   (B) A high resistance in series
   (C) A low resistance in parallel
   (D) A high resistance in parallel

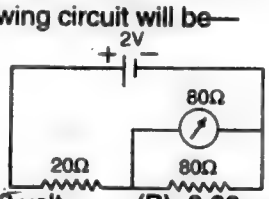
5. An ammeter should have very low resistance—
   (A) For large deflection
   (B) For better stability
   (C) So that it may not burn out
   (D) So that it may not change the value of current by its presence
   (CPMT)

6. A DC milliameter has a resistance of 12Ω and gives full scale deflection for a current of 0·01 A. To convert it into a voltmeter giving a full scale deflection for 3V, the resistance required to be put in series with the instrument is—
   (A) 102 Ω (B) 288 Ω
   (C) 300 Ω (D) 412 Ω

7. The deflection in a moving coil galvanometer falls from 50 to 10 divisions when a shunt of 12 Ω is connected across it. The resistance of the galvanometer coil is—
   (A) 24 Ω (B) 36 Ω
   (C) 48 Ω (D) 60 Ω

8. A voltmeter having a resistance of 1800 Ω is employed to measure the potential difference across a 200 Ω resistor which is connected to the terminals of a DC power supply having an e.m.f. of 50V and an internal resistance of 20Ω. What is the percentage decrease in the potential difference across the 200 Ω resistor as a result of connecting the voltmeter across it ?
   (A) 1% (B) 5%
   (C) 10% (D) 25%

9. The reading of voltmeter in the following circuit will be—



   (A) 2 volt (B) 0·80 volt
   (C) 1·33 volt (D) 1·60 volt

10. A galvanometer of resistance 100Ω gives full scale deflection for 10 mA current. What should be the value of shunt so that it can measure a current of 100 mA ?
    (A) 11·11 Ω (B) 9·9 Ω
    (C) 1·1 Ω (D) 4·4 Ω

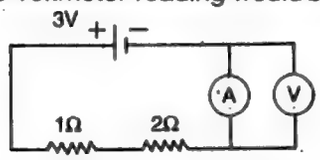
11. A galvanometer of resistance 100 Ω gives full scale deflection for a current of 10^{-5} A. The shunt required to convert it into an ammeter of 1 ampere range will be—
    (A) 10^{-2} Ω (B) 1 Ω
    (C) 10^{-1} Ω (D) 10^{-3} Ω

12. The resistance of a moving coil galvanometer is 20Ω. It requires 0·01 ampere current for full scale deflection. The value of resistance required to convert it into a voltmeter of range 20 volt will be—
    (A) 198 Ω (B) 1980 Ω
    (C) 20 Ω (D) 0 Ω

13. The deflection of a moving coil galvanometer reduces to half on shunting it with a resistance of 60Ω. The resistance of galvanometer is—
    (A) 30 Ω (B) 120 Ω
    (C) 60 Ω (D) 15 Ω

14. A moving coil voltmeter is generally used in laboratory to measure potential difference across a conductor of resistance *r* carrying a current. The voltmeter has a resistance R and will measure the potential difference more correctly as—
    (A) R approaches *r*
    (B) R equal zero
    (C) R becomes larger than *r*
    (D) R becomes smaller than *r*

15. In the circuit shown in the figure, the voltmeter reading would be—



(A) 0 volt (B) 0·5 volt
(C) 1 volt (D) 2 volt

A and V are ideal ammeter and voltmeter respectively.

16. To measure very low resistance we should use—
(A) Wheatstone bridge
(B) Kelvin's double bridge
(C) Potentiometer
(D) Voltmeter and ammeter

17. In the experiment of calibration of voltmeter, a standard cell of e.m.f. 1·1 volt is balanced against 440 cm of potentiometer wire. The potential difference across the ends of a resistance is found to balance against 220 cm of the wire. The corresponding reading of voltmeter is 0·5 volt. The error in the reading of voltmeter will be—
(A) − 0·15 volt
(B) 0·15 volt
(C) 0·5 volt
(D) − 0·05 volt

18. In a potentiometer experiment, a standard cell of e.m.f. 1·2 V gets balanced at 260 cm length of potentiometer wire. If a current of 0·2A flows through 3·5Ω resistance then balancing length will be—
(A) 151·66 cm (B) 130 cm
(C) 520 cm (D) 80 cm

19. If the radius of a potentiometer wire is increased four times, keeping its length constant then the value of its potential gradient will—
(A) Become four times
(B) Become two times
(C) Become half
(D) Remain constant

20. If the applied e.m.f. in the primary circuit of a potentiometer is increased three times than the value of potential gradient will become—
(A) One third (B) Three times
(C) Six times (D) Nine times

21. A potentiometer gives null deflection at 350 cm when connected between the points X and Y. When the potentiometer terminal at Y is connected at Z, the null deflection is obtained at 50 cm. If the potentiometer is connected between Y and Z then the null point will be obtained at—
(A) 350 cm (B) 250 cm
(C) 150 cm (D) 300 cm

22. A potentiometer wire of length 10 m and resistance 9·8 Ω is connected in series with a battery of e.m.f. 2 volt and internal resistance 0·2 Ω. The balancing length for a cell of e.m.f. 1 volt on this potentiometer is 4 m. When a 2Ω resistance is connected in series with the potentiometer wire, then change in balancing length will be—
(A) Decrease by 0·8 m
(B) Increase by 1m
(C) Decrease by 1m
(D) Increase by 0·8 m

23. The balancing lengths corresponding to two cells are in the ratio 2 : 1. When the cells are connected so as to support each other then balancing length is l_1. When they are connected so as to oppose each other, the balancing length is l_2. The value of $l_1 : l_2$ will be—
(A) 3 : 1 (B) 1 : 2
(C) 1 : 1 (D) 2 : 1

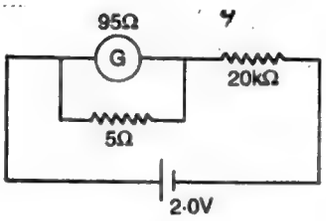
24. A current I flows when a resistance R is connected across the terminals of a cell. The value of current when resistance R is replaced by R/2 will be—
(A) Less than 2I
(B) 2I
(C) I
(D) More than 2I

ANSWERS

1. (B) 2. (A) 3. (D) 4. (B) 5. (D)
6. (B) 7. (C) 8. (A) 9. (C) 10. (A)
11. (D) 12. (B) 13. (C) 14. (C) 15. (A)
16. (B) 17. (D) 18. (A) 19. (D) 20. (B)
21. (D) 22. (D) 23. (A) 24. (A)

HINTS

2.



Current in 20 kΩ resistance

$$= \frac{2\cdot0}{\frac{95\times5}{100}+20\times10^3}$$

$$\approx 10^{-4}\ A$$

$$= 100\ \mu A$$

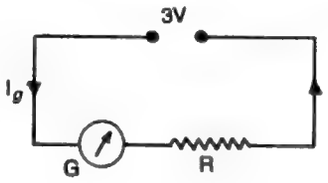
∴ Current sensitivity

$$= \frac{\theta}{I}$$

$$= \frac{50}{100}\ (\text{divisions}/\mu A)$$

$$= 0\cdot5\ (\text{divisions}/\mu A)$$

6.

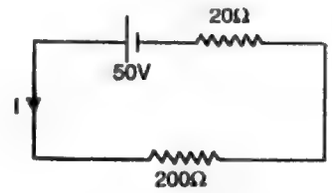


$$I_g = \frac{V}{R+G}$$

$$\frac{1}{100} = \frac{3}{R+12}$$

$$\Rightarrow \quad R = 288\ \Omega$$

8.



Current through 200Ω resistor

$$I = \frac{50}{200+20} = \frac{50}{220}$$

$$= \frac{5}{22}\ A$$

Potential drop across 200 Ω resistor

$$= \frac{5}{22}\times200$$

$$= \frac{500}{11}\ \text{volt}$$

When a voltmeter of resistance 1800 Ω is connected across it, its effective resistance R will be

$$\frac{1}{R} = \frac{1}{1800} + \frac{1}{200}$$

or, $R = 180\ \Omega$

Now, the current

$$I' = \frac{50}{180 + 20}$$

$$= \frac{50}{200} = \frac{1}{4}\ A$$

Potential drop across resistor

$$= \frac{1}{4} \times 180$$

$$= 45 \text{ volt}$$

∴ Change in potential difference in two cases

$$= \frac{500}{11} - 45 = \frac{5}{11}$$

Percentage change

$$= \frac{5}{11} \times \frac{11}{500} \times 100$$

$$= 1\%$$

9. Total resistance of the circuit

$$= 20 + \frac{80 \times 80}{80 + 80}$$

$$= 60\ \Omega$$

∴ Current

$$I = \frac{V}{R} = \frac{2}{60} = \frac{1}{30} \text{ amp}$$

∴ The reading of voltmeter

$$= IR'$$

$$= \frac{1}{30} \times \left(\frac{80 \times 80}{80 + 80}\right)$$

$$= \frac{1}{30} \times 40$$

$$= 1{\cdot}33 \text{ volt}$$

10. $\boxed{S = \frac{G}{(n-1)}}$

where, $n = \frac{\text{new range}}{\text{old range}}$

$$= \frac{100}{10} = 10$$

∴ $S = \frac{100}{10 - 1}$

$$= \frac{100}{9} = 11{\cdot}11\ \Omega$$

Second Method :

$$I_g = I\frac{S}{G + S}$$

$$10 = 100\frac{S}{100 + S}$$

$$\Rightarrow S = \frac{100}{9} = 11{\cdot}11\ \Omega$$

11. $I_g = I\frac{S}{G + S}$

$$10^{-5} = 1\frac{S}{100 + S}$$

$$\Rightarrow S \approx 10^{-3}\ \Omega$$

Aliter :

$$S = \frac{I_g}{I - I_g} G$$

$$= \frac{10^{-5}}{1 - 10^{-5}} \times 100$$

$$\approx 10^{-3}\ \Omega$$

12. $R = \frac{V}{I_g} - G$

$$= \frac{20}{0{\cdot}01} - 20$$

$$= 1980\ \Omega$$

13. The current is divided equally in two resistances in parallel only when their values are same.

∴ $G = 60\ \Omega$

17. $x = \frac{E_s}{L} = \frac{1{\cdot}1}{440}$

$$= 0{\cdot}0025 \text{ V/cm}$$

Potential difference across R

$$= 0{\cdot}0025 \times 220$$

$$= 0{\cdot}55 \text{ volt}$$

Error in the reading of voltmeter

= Reading of voltmeter – reading of potentiometer

$$= 0{\cdot}5 - 0{\cdot}55$$

$$= -0{\cdot}05 \text{ volt.}$$

18. $V = IR$

$$= xl$$

$$= \frac{E_s}{L} l$$

∴ $l = \frac{IRL}{E_s}$

$$= \frac{0{\cdot}2 \times 3{\cdot}5 \times 260}{1{\cdot}2}$$

$$= 151{\cdot}66 \text{ cm}$$

20. Since potential gradient ∝ e.m.f. of the source

∴ On increasing the e.m.f. three times, the potential gradient will also increase three times.

21. Potential difference between X and Y is

$$V_{XY} = 350\ x$$

and potential difference between X and Z is

$$V_{XZ} = 50\ x$$

∴ $V_{YZ} = V_{XY} - V_{XZ}$

$$= 350\ x - 50\ x$$

$$= 300\ x$$

∴ $l = 300 \text{ cm}$

22. $V = xl$

$$= x'l'$$

$$\frac{ER_p}{(R_p + r)L} \times 4 = \frac{ER_p}{(R + R_p + r)\ L} \times l'$$

$$\frac{4}{(9{\cdot}8 + 0{\cdot}2)} = \frac{l'}{(2 + 9{\cdot}8 + 0{\cdot}2)}$$

∴ $\frac{4}{10} = \frac{l'}{12}$

$$l' = 4{\cdot}8 \text{ m}$$

∴ $l' - l = 4{\cdot}8 - 4$

$$= 0{\cdot}8 \text{ m increase}$$

23. When cells support to each other

$$E_1 + E_2 = xl_1$$

When cells oppose to each other,

$$E_1 - E_2 = xl_2$$

or, $\frac{l_1}{l_2} = \frac{E_1 + E_2}{E_1 - E_2}$

$$= \frac{\frac{E_1}{E_2} + 1}{\frac{E_1}{E_2} - 1}$$

$$= \frac{2 + 1}{2 - 1}$$

$$= 3 : 1$$

24. $I = \frac{E}{R + r}$

and $I' = \frac{E}{\frac{R}{2} + r}$

which is less than $\frac{E}{\frac{R}{2} + \frac{r}{2}}$ or 2I.

●●●

PHYSICS

1. The neutron was discovered by—
   (A) Marie Curie
   (B) Pierre Curie
   (C) James Chadwick
   (D) Rutherford

2. Electric field can deflect—
   (A) X-rays (B) α-particles
   (C) γ-rays (D) Neutrons

3. The characteristic X-ray radiation is emitted when—
   (A) The electrons are accelerated to a fixed energy
   (B) The source of electrons emits a monoenergetic beam
   (C) The bombarding electrons knock out electrons from the inner shell of the target atoms and one of the outer electrons falls into this vacancy.
   (D) The valance electrons in the target atoms are removed as a result of the collision

4. The voltage across a diode is increased in small steps and the current passing through it recorded at each step. The current—
   (A) Is always proportional to voltage applied
   (B) Rises to a maximum then falls to zero
   (C) Remains constant all the time
   (D) Increases with voltage but not proportionally to it

5. The total energy of the electron of H-atom in the second quantum state is $-E_2$. The total energy of the He atom in the third quantum state is—
   (A) $-\frac{3}{2}E_2$ (B) $-\frac{2}{3}E_2$
   (C) $-\frac{4}{9}E_2$ (D) $-\frac{16}{9}E_2$

6. Radio waves of constant amplitude are generated by—
   (A) Rectifier
   (B) Electron transition
   (C) Oscillator
   (D) Amplifier

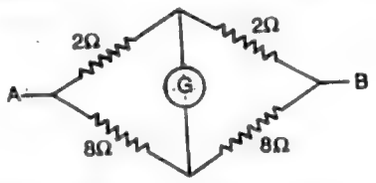
7. The coefficient of self-inductance of a coil is 100 μH and the current flowing in it changes from 1·5 amp to 1 amp in 10μ second. The value of induced e.m.f. is—
   (A) 50 volt (B) 5 volt
   (C) 0·5 volt (D) 0·05 volt

8. The maximum amount of heat that can be given to 1 g of water without change of temperature is—
   (A) 2268 J (B) 6468 J
   (C) 336 J (D) 4200 J

9. An extremely hot star would look—
   (A) Violet or indigo
   (B) Green or yellow
   (C) Orange or red
   (D) White

10. A wire of resistance R is doubled by stretching. The resistance of half of this stretched wire will be—
    (A) 4R (B) 2R
    (C) R (D) $\frac{R}{2}$

11. What is the equivalent resistance between A and B in the following figure—



    (A) 2·3 Ω (B) 3·2 Ω
    (C) 4 Ω (D) $\frac{11}{2}$ Ω

12. A charge q is placed at the centre of the line joining two equal charges Q. The system of the three charges will be in equilibrium if q is equal to—
    (A) $-\frac{Q}{2}$ (B) $-\frac{Q}{4}$
    (C) $+\frac{Q}{4}$ (D) $+\frac{Q}{2}$

13. A ray of unpolarised light is incident on a glass plate at the polarising angle. Then—
    (A) The reflected and transmitted rays will be completely plane polarised
    (B) The reflected ray will be completely polarised and the transmitted ray will be partially polarised.
    (C) The reflected ray will be partially polarised and the transmitted ray will be completely polarised.
    (D) The reflected and the transmitted ray will be partially polarised

14. In a Young's double slit experiment the source slit S and the two slits A and B are horizontal with slit A above slit B. The fringes are observed on a vertical screen K. The optical path length from S to B is increased very slightly (by introducing a transparent material of higher refractive index) and the optical path length from S to A is not changed, as a result the fringe system on K moves—
    (A) Vertically downwards slightly
    (B) Vertically upwards slightly
    (C) Horizontally, slightly to the left
    (D) Horizontally, slightly to the right

15. While passing over an obstacle a light ray slightly bends round the corner. The phenomenon is known as—
    (A) Scattering
    (B) Polarisation
    (C) Diffraction
    (D) Total internal reflection

16. A convex lens of focal length 0·5 m and a concave lens of focal length 1m are placed in contact. Power of the combination is—
    (A) 1 D (B) 0·5 D
    (C) −1 D (D) −0·5 D

17. A small pin fixed on a table top is viewed from above from a distance of 50 cm. By what distance would the pin appear to be raised if it is viewed from the same point through a 15 cm thick glass slab held parallel to the table ? Refraction index of glass = 1·5—

(A) 5 cm (B) 3 cm
(C) 6 cm (D) 10 cm

18. A pool of water (refractive index $= \frac{4}{3}$) is 60 cm deep. What is apparent depth when view vertically through air ?
(A) 40 cm (B) 50 cm
(C) 45 cm (D) 54 cm

19. The sun is visible to us a little before the actual sunrise and a little after the actual sunset. This is because of atmospheric—
(A) Reflection (B) Refraction
(C) Scattering (D) Diffraction

20. Sound travels in rocks in the form of—
(A) Longitudinal elastic waves only
(B) Transverse elastic waves only
(C) Both longitudinal and transverse elastic waves
(D) Non-elastic waves

21. The equation of a transverse wave is given by :
$y = 10 \sin \pi (0{\cdot}01\, x - 2t)$
where x and y are in cm and t is in second. Its frequency is—
(A) $10\ sec^{-1}$ (B) $2\ sec^{-1}$
(C) $1\ sec^{-1}$ (D) $0{\cdot}01\ sec^{-1}$

22. If two tuning forks A and B are sounded together, they produce 4 beats per second. A is then slightly loaded with wax, they produce 2 beats when sounded again. The frequency of A is 256. The frequency of B will be—
(A) 250 (B) 252
(C) 260 (D) 262

23. The air pressure at a height h is given by—
(A) $P = P_0 e^{\alpha h^2}$ (B) $P = P_0 e^{-\alpha h^2}$
(C) $P = P_0 e^{-\alpha h}$ (D) $P = P_0 e^{\alpha h}$

24. A square plate of 10 cm side moves parallel to another plate with a velocity of 10 cm s^{-1}, both the plates being immersed in water. If the viscous force is 200 dyne and viscosity of water is 0·01 poise, what is their distance apart ?
(A) 0·005 cm (B) 5·0 cm
(C) 0·5 cm (D) 0·05 cm

25. If the excess pressure inside a spherical soap bubble of radius 10 mm is balanced by that due to a column of oil of specific gravity 0·9, 1·36 mm high, calculate the surface tension—
(A) 30·02 dyne cm^{-1}
(B) 3·002 dyne cm^{-1}
(C) 0·3002 dyne cm^{-1}
(D) 20·30 dyne cm^{-1}

26. When the displacement is half of the amplitude, then what fraction of total energy of a simple harmonic oscillator is kinetic ?
(A) $\frac{3}{4}$th (B) $\frac{2}{7}$th
(C) $\frac{5}{7}$th (D) $\frac{2}{9}$th

27. The escape velocity of an object from the earth depends upon the mass of the earth (M), its mean density (ρ), its radius (R) and the gravitational constant (G). Thus the formula for escape velocity is—
(A) $v = R\sqrt{\frac{8\pi G\rho}{3}}$
(B) $v = M\sqrt{\frac{8\pi GR}{3}}$
(C) $v = \sqrt{GMR}$
(D) $v = \sqrt{\frac{2GM}{R^2}}$

28. A particle of mass m is moving in a horizontal circle of radius r, under a centripetal force equal to $-\frac{k}{r^2}$, where k is a constant. The total energy of the particle is—
(A) $\frac{k}{2r}$ (B) $-\frac{k}{2r}$
(C) $-\frac{k}{r}$ (D) $\frac{k}{r}$

29. The coefficient of restitution for a perfectly elastic collision is—
(A) 1 (B) 0
(C) ∞ (D) −1

30. The valency of the impurity atom that is to be added to germanium crystal so as to make it a n-type semiconductor is—
(A) 6 (B) 5
(C) 4 (D) 3

31. With rise in temperature, the specific resistance of semiconductors—
(A) Increases
(B) Decreases
(C) Remains unchanged
(D) First decreases then increases

32. A person can not see objects beyond 50 cm. He must use lens of power—
(A) −2D (B) +2D
(C) +4D (D) −4D

33. The susceptibility of a substance is $-0{\cdot}1 \times 10^{-8}$ S.I. The substance could be—
(A) Copper (B) Iron
(C) Nickel (D) Aluminium

34. The work done in moving a charge of 2×10^{-9} C from a point of potential − 3000 V to another point P is 5×10^{-5} J. Find the potential at the point P—
(A) 22000 V (B) 2500 V
(C) 30000 V (D) 3200 V

35. A blackened platinum wire of length 5 cm and perimeter 0·02 cm is maintained at a temperature of 3000 K. At what rate is the wire losing its energy ? ($\sigma = 5{\cdot}67 \times 10^{-5}$ c.g.s. units)
(A) 54·927 watt
(B) 27·945 watt
(C) 45·927 watt
(D) 94·527 watt

36. A 40 watt daylight bulb has a tungsten filament of surface area 0·25 cm^2. What is the temperature of the filament when it reaches incandescence. Emissivity of the filament = 0·35, $\sigma = 5{\cdot}67 \times 10^{-5}$ cgs units. J = 4·18 J/cal—
(A) 9296 K (B) 8096 K
(C) 9629 K (D) 2996 K

37. Calculate the Hall constant for silver knowing its density, $\rho = 10{\cdot}5 \times 10^3\ kg/m^3$ and atomic mass A = 107·868, of Avogadro's no. $N = 6{\cdot}02 \times 10^{26}$ per kg mol—
(A) $1{\cdot}07 \times 10^{-10}\ m^3/C$
(B) $1{\cdot}07 \times 10^{10}\ m^3/C$
(C) $7{\cdot}01 \times 10^{-10}\ m^3/C$
(D) $10{\cdot}7 \times 10^{10}\ m^3/C$

38. If $\vec{A} + \vec{B} = \vec{A} - \vec{B}$, then which of the following is correct ?
(A) $\vec{A} = 0$

(B) $\vec{B} = 0$

(C) $\vec{A}$ and $\vec{B}$ are simultaneously zero

(D) $\vec{A} + \vec{B} = 0$

39. The radioactivity of a sample is R_1 at time T_1 and R_2 at a time T_2. If the half-life of the specimen is T, the number of atoms that have disintegrated in time $(T_2 - T_1)$ is proportional to—
(A) $(R_1T_1 - R_2T_2)$
(B) $(R_1 - R_2)$
(C) $(R_1 - R_2)/T$
(D) $(R_1 - R_2)T$

40. The probability of a radioactive atom to survive 5 times larger than its half value period is—
(A) $\frac{2}{5}$ (B) 2×5
(C) 2^{-5} (D) 2^5

41. Van de Graff generator is used to—
(A) Detect charged particles
(B) Count charged particles
(C) Accelerate charged particles
(D) Accelerate neutrons

42. An electrical strain gauge is—
(A) A thermistor
(B) A triode with more than one grid
(C) A mesh of wire under strain
(D) A resistor whose resistance alters with changes in stress

43. The position coordinates of a particle with respect to time are $x = ct^2$ and $y = bt^2$. The speed of the particle is—
(A) $2t(b + c)$ (B) $2t\sqrt{c^2 - b^2}$
(C) $t\sqrt{b^2 + c^2}$ (D) $2t\sqrt{b^2 + c^2}$

44. The correct dimensions of permeability and permittivity are respectively as—
(A) $M^{-1} L^{-3} T^3 Q^2$, MLQ^{-2}
(B) MLQ^{-2}, $M^{-1} L^{-3} T^2 Q^2$
(C) MLQ^{-1}, $M^{-1} L^{-3} T^2 Q$
(D) $M^{-1} L^{-3} T^3 Q$, MLQ^{-1}

45. Radiators heat rooms—
(A) Chiefly by convection
(B) By radiation
(C) By conduction
(D) By radiation and conduction both

ANSWERS

1. (C) 2. (B) 3. (C) 4. (D) 5. (D)
6. (C) 7. (B) 8. (A) 9. (A) 10. (B)
11. (B) 12. (B) 13. (B) 14. (B) 15. (C)
16. (A) 17. (A) 18. (C) 19. (B) 20. (C)
21. (C) 22. (B) 23. (C) 24. (D) 25. (A)
26. (A) 27. (A) 28. (B) 29. (A) 30. (B)
31. (B) 32. (A) 33. (A) 34. (A) 35. (C)
36. (D) 37. (A) 38. (B) 39. (C) 40. (C)
41. (C) 42. (D) 43. (D) 44. (B) 45. (A)

HINTS

5. The energy of the nth quantum state of hydrogen atom is $-\frac{13.6}{n^2}$ eV. For other hydrogen like atoms it is $\frac{-13.6Z^2}{n^2}$ eV. Here

$$E_2 = \frac{-13.4}{4} \ (n = 2)$$
$$= -3.4 \text{ eV}.$$

For helium atom at third quantum state,

$$E_3 = -\frac{13.6Z^2}{n^2}$$
$$= -\frac{13.6 \times 2^2}{3^2}$$
$$= -\frac{13.6 \times 4}{9}$$
$$= -\frac{13.6 \times 4 \times 4}{4 \times 9}$$
$$= -3.4 \times \frac{16}{9}$$
$$= -E_2\left(\frac{16}{9}\right)$$

7. $e = -L\frac{dI}{dt}$

$$= -\frac{100 \times 10^{-6} \times (1 - 1.5)}{10 \times 10^{-6}}$$
$$= 5 \text{ volt}$$

8. 1 gram of water will remain so only upto 100°C. After that it becomes steam at constant temperature 100°C. Heat required to vaporise $= m \times L = 2.268 \times 10^6$ J, for 1 kg or 2268 J for 1 g.

9. By Wien's displacement law $\lambda_m T$ = constant, where λ_m is the wavelength of radiators carrying maximum energy and T is the temperature of the star. For a very hot star T is high. So λ_m is low. Lower wavelength corresponds to the violet region.

10. When length is doubled, area of cross-section reduces to half, because volume is same. The resistance of the wire due to these changes becomes four times (resistance is proportional to length and inversely proportional to area). Half of the wire will have a resistance 2R.

11. Equivalent resistance of upper arm R = 2 + 2 = 4Ω (series)
Equivalent resistance of lower arm

$$R' = 8 + 8$$
$$= 16 \ \Omega \text{ (series)}$$

Equivalent of R and R'

$$= R^* = \frac{RR'}{R + R'} \text{ (parallel)}$$
$$= \frac{4 \times 16}{4 + 16} = 3.2 \ \Omega$$

12.

q will be in equilibrium if electrostatic force of repulsion between Q and Q = electrostatic force of attractions between q and Q.

$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q \times Q}{(2r)^2}$$
$$= -\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q \times q}{r^2}$$

(negative for attractive force)

$$\frac{Q^2}{4r^2} = -\frac{Q \cdot q}{r^2}$$
$$q = -\frac{Q}{4}$$

16. Power of convex lens

$$P_1 = \frac{1}{f} = \frac{1}{0.5} = 2D$$

Power of concave lens

$$P_2 = -\frac{1}{f} = -\frac{1}{1} = -1D$$

Power of combination

$$P = P_1 + P_2$$
$$= 2 - 1 = 1D$$

17. If y is the distance through which the pin would appear to be raised, then

y = Real thickness of slab – Apparent thickness of slab
$= \text{Real thickness} - \frac{\text{Real thickness}}{\mu}$

$= \text{Real thickness}\left(1-\frac{1}{\mu}\right)$

$= 15\left(1-\frac{1}{1\cdot5}\right)$

$= 5$ cm

18. Refractive index

$= \frac{\text{Real depth}}{\text{Apparent depth}}$

Apparent depth

$= \frac{\text{Real depth}}{\text{Refractive index}}$

$= \frac{60}{4/3} = \frac{60\times3}{4}$

$= 45$ cm

21. Standard wave equation is

$y = a\sin\omega\left(t-\frac{x}{v}\right)$

The given equation is

$y = 10\sin\pi(0\cdot01x-2t)$

On comparison we get,

$\omega = 2\pi$

$2\pi n = 2\pi$

$\Rightarrow \quad n = 1\ \text{sec}^{-1}$

22. The frequency of B may be either 256 + 4 = 260 or 256 − 4 = 252. Since the frequency of A will decrease on waxing. Hence, the frequency of B will be 252.

24. Area $A = 10\text{ cm}\times10\text{ cm}$

$= 100\text{ cm}^2$

Velocity, dv

$= 10\text{ cm s}^{-2}$;

Viscous force,

$F = 200$ dyne

Coefficient of viscosity,

$\eta = 0\cdot01$ poise,

Distance,

$dx = ?$

$F = \eta A\frac{dv}{dx}$

$dx = \frac{\eta A dv}{F}$

$= \frac{0\cdot01\times100\times10}{200}$

$= 0\cdot05$ cm

25. Radius $r = 10\text{ mm} = 1$ cm,

Density $\rho = 0\cdot9\text{ g cm}^{-3}$

Height $h = 1\cdot36$ mm

$= 0\cdot136$ cm

Excess pressure

$P = h\rho g$

$= 0\cdot136\times0\cdot9\times$ 981 dyne cm^{-2}

$P = \frac{4T}{r}$

$T = \frac{Pr}{4} = \frac{0\cdot136\times0\cdot9\times981\times1}{4}$

$= 30\cdot02$ dyne cm^{-1}

26. Since

$\text{K. E.} = \frac{1}{2}m\omega^2(a^2-y^2)$

$= \frac{1}{2}m\omega^2\left(a^2-\frac{a^2}{4}\right)$

$= \frac{1}{2}m\omega^2a^2\cdot\frac{3}{4}$

Total energy,

$E = \frac{1}{2}m\omega^2a^2$

$\therefore \frac{\text{K. E.}}{E} = \frac{1}{2}m\omega^2a^2\cdot\frac{3}{4}\times\frac{2}{m\omega^2a^2}$

$= \frac{3}{4}$

27. $v_e = \sqrt{2gR}$,

$g = \frac{GM}{R^2}$

and $\rho = \frac{M}{\frac{4\pi}{3}R^3}$

$\Rightarrow \quad M = \frac{4\pi}{3}\rho R^3$

$\therefore \quad g = G\cdot\frac{4\pi}{3}\rho R$

$\Rightarrow \quad V_e = \sqrt{2gR}$

$= \sqrt{\frac{8\pi}{3}G\rho R^2}$

$= R\sqrt{\frac{8\pi}{3}G\rho}$

28. Here $\frac{mv^2}{r} = \frac{k}{r^2}$

$\Rightarrow \quad v^2 = \frac{k}{mr}$

$\text{K. E.} = \frac{1}{2}mv^2$

$= \frac{1}{2}m\times\frac{k}{mr}$

$= \frac{k}{2r}$

$\text{P. E. U.} = -\int_{\infty}^{r}F\cdot dr$

$= -\int_{\infty}^{r}-\frac{k}{r^2}\cdot dr$

$= -\frac{k}{r}$

$\therefore$ Total energy = K. E. + P. E.

$= \frac{k}{2r}-\frac{k}{r}$

$= -\frac{k}{2r}$

31. The temperature coefficient of semiconductors is negative.

32. This is a case of myopia. Since the person can not see the objects placed beyond 50 cm, the lens he uses should bring all objects placed beyond 50 cm to infinity, at 50 cm.

$\frac{1}{v}+\frac{1}{u} = \frac{1}{f}$

$-\frac{1}{50}-\frac{1}{\infty} = \frac{1}{f}$

$\Rightarrow \quad f = -50$ cm

$\text{Power} = \frac{100}{f}$

$= \frac{100}{-50}$

$= -2\text{D}$

In short, a person suffering from short sight should wear a concave lens, where focal length is equal to the farther distance he can see.

33. The susceptibility of a dimagnetic substance is negative. Here the only diamagnetic substance is copper.

34. Let V be the potential at P. Then potential difference between the two points

$= V-(-3000)$

$= (V+3000)\text{ V}$

This is equal to the work done in taking 1C of positive charge from P to the other point.

$\therefore \quad V+3000 = \frac{\text{Work}}{\text{Charge}}$

$= \frac{5\times10^{-5}}{2\times10^{-9}}$

or, $V+3000 = 25000$

$\Rightarrow \quad V = 22000\text{ V}$

35. $P = \frac{e A\sigma T^4}{10^7}$ watt

$= \frac{1\times5\times0\cdot02\times5\cdot67\times10^{-5}\times3000^4}{10^7}$

$= 45\cdot927$ watt

36. $P = \frac{e A \sigma T^4}{10^7}$ watt

$$T = \left[\frac{P \times 10^7}{e A \sigma}\right]^{1/4}$$

$$= \left[\frac{40 \times 10^7}{0{\cdot}35 \times 0{\cdot}25 \times 5{\cdot}67 \times 10^{-5}}\right]^{1/4}$$

$$= 2996 \text{ K}$$

37. The reciprocal of '*ne*' is called Hall constant.

$$\therefore C_H = \frac{1}{ne}$$

But $n = \frac{\rho N}{A}$

$$\therefore C_H = \frac{A}{\rho N e}$$

$$= \frac{107{\cdot}868}{10{\cdot}5 \times 10^3 \times 6{\cdot}02 \times 10^{26} \times 1{\cdot}6 \times 10^{-19}}$$

$$= 1{\cdot}07 \times 10^{-10} \text{ m}^3/\text{C}$$

39. Radioactivity at time T_1

$$= R_1 = \lambda N_1$$

Radioactivity at time T_2

$$= R_2 = \lambda N_2$$

$\therefore$ No. of atoms decayed in time $(T_2 - T_1) = (N_1 - N_2)$

$$= \frac{R_1 - R_2}{\lambda}$$

$$= \frac{(R_1 - R_2)}{0{\cdot}693/T}$$

$$= \frac{(R_1 - R_2)T}{0{\cdot}693}$$

$$\propto (R_1 - R_2)\, T$$

40. Time of decay

= Half-life × No. of half-lives

$$t = t_{1/2} \times n$$

$$5\, t_{1/2} = t_{1/2} \times n \quad \text{(Given } t = 5\, t_{1/2}\text{)}$$

$$\Rightarrow \quad n = 5$$

Survival probability of a radioactive atom

$$= \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$$

$$= \left(\frac{1}{2}\right)^5 = 2^{-5}$$

43. Velocity along *x*-axis =

$$v_x = \frac{dx}{dt} = 2\, ct$$

Velocity along *y*-axis =

$$v_y = \frac{dy}{dt} = 2bt$$

Velocity of the particle =

$$v = \sqrt{v_x^2 + v_y^2}$$

$$= \sqrt{(2ct)^2 + (2bt)^2}$$

$$= 2t\sqrt{b^2 + c^2}$$

44. The basic expression are

$$F = \frac{\mu_0}{2\pi} \frac{I_1 I_2 l}{d}$$

and $F = \frac{q_1 q_2}{4\pi\varepsilon_0 \cdot d^2}$

$$\therefore \quad \mu_0 = \frac{\text{Newton}}{\text{Ampere}^2}$$

$$= \frac{[MLT^{-2}]}{\left[\frac{Q}{T}\right]^2}$$

$$= [MLQ^{-2}]$$

and $\varepsilon_0 = \frac{\text{Coulomb}^2}{\text{Newton} \times \text{Metre}^2}$

$$= \frac{[Q^2]}{[MLT^{-2}] \times [L^2]}$$

$$= [M^{-1} L^{-3} T^2 Q^2]$$

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PHYSICS

1. An ideal gas is confined to a cylinder fitted with a piston. The piston is slowly pushed in so that the gas temperature remains at 27° C. During compression 730 J of work is done on the gas. Find the change in the entropy of the gas—
   (A) 10·25 J/K (B) Zero
   (C) 4·30 J/K (D) – 2·43 J/K

2. One half mole of helium gas is confined to a container at STP. How much heat energy is needed to double the pressure of the gas ?
   [Molar specific heat of gas at constant volume = 12·4 J/mole K]
   (A) 2500 J (B) 1000 J
   (C) 1693 J (D) 3000 J

3. The sun's surface temperature is about 6000 K. The sun's radiation is maximum at a wavelength of 0·5 μm. If both the surface of the sun and the filament emitting maximum radiation at a wavelength of 2μm have, the same emissive characteristics, calculate the temperature of the filament—
   (A) 1500 K (B) 2000 K
   (C) 1000 K (D) 500 K

4. At what temperature is the effective speed of hydrogen molecule (molecular weight = 2) equal to that of oxygen molecule at 47° C ? Molecular weight of oxygen is 32
   (A) 10 K (B) 20 K
   (C) 30 K (D) 40 K

5. Find the magnetic energy stored in an air core solenoid of length 30 cm and radius 1 cm. The number of turns in the solenoid is 200 and steady current flowing through the coil is 3A—
   (A) $73{\cdot}2 \times 10^{-3}$ J
   (B) $23{\cdot}7 \times 10^{2}$ J
   (C) $2{\cdot}37 \times 10^{-3}$ J
   (D) $12{\cdot}37 \times 10^{3}$ J

6. A potentiometer wire is 100 cm long and a constant potential difference is maintained across it. Two cells A and B are connected in series first to support one another and then in opposition. The balance points are obtained at 60 cm and 12 cm from the same end of the wire. Find the ratio of the emf's—
   (A) 3 : 2 (B) 2 : 5
   (C) 1 : 3 (D) 4 : 7

7. The focal lengths of the objective and the eyepiece of an astronomical telescope are 20 cm and 5 cm respectively. If the final image Is formed at a distance of 30 cm from the eyepiece, find the separation between the lenses for distinct vision and normal vision—
   (A) 24·3 cm, 25 cm
   (B) 30 cm, 15 cm
   (C) 35 cm, 40 cm
   (D) 10 cm, 20 cm

8. Complete the equation for the following fission process
   $_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{38}Sr^{90} + ...$
   (A) $_{54}X^{143} + 3{}_{0}n^{1}$
   (B) $_{54}X^{145} + 3{}_{0}n^{1}$
   (C) $_{57}X^{142} + 3{}_{0}n^{1}$
   (D) $_{54}X^{142} + {}_{0}n^{1}$

9. The vectors $\hat{i} + 3\hat{j} + 5\hat{k}$ and $2\hat{i} + 6\hat{j} + 10\hat{k}$ are—
   (A) Parallel
   (B) Perpendicular
   (C) Inclined at 135°
   (D) Inclined at 60°

10. To use a transistor as an amplifier—
    (A) No biasing voltages are required
    (B) Both the junctions are forward biased
    (C) Both the junctions are reverse biased
    (D) The emitter-base junction is forward biased and the base-collector junction is reverse biased

11. If there are 4 atoms per unit cell in a solid, the crystal is—
    (A) Tetragonal
    (B) Simple cubic
    (C) Body-centred cubic
    (D) Face-centred cubic

12. An electron with kinetic energy = E eV collides with a hydrogen atom in the ground state. The collision will be elastic—
    (A) For all values of E
    (B) For E < 10·2 eV
    (C) For E < 13·6 eV
    (D) Only for E < 3·4 eV

13. A choke of 0·5 H, a capacitor of 15μF and a resistance of 100 ohm are connected in series across 200 volt, 50 Hz mains. The current and the power factor of the circuit are—
    (A) 1·75 A, 0·8759
    (B) 17·5A, 87·59
    (C) 7·15A, 78·5
    (D) 71·5A, 7·85

14. An oscillator circuit contains an inductance 0·04H and a capacitor of capacity 16μF. Determine the maximum current when the maximum voltage across the capacitor is 150V—
    (A) 1A (B) 2A
    (C) 3A (D) 4A

15. A wire with mass per unit length 5g/mm is stretched between two rigid supports with a tension 4·5 N. It resonates at the frequency of 420 Hz. If the next occurs at 490 Hz, find the length of the wire—
    (A) 3 m (B) 14 m
    (C) 10 m (D) $\frac{3}{14}$ m

ANSWERS WITH HINTS

1. (D) 2. (C) 3. (A) 4. (B) 5. (C)
6. (A) 7. (A) 8. (A) 9. (A) 10. (D)
11. (D) 12. (B) 13. (A) 14. (C) 15. (D)

1. From the first law of thermodynamics

$$\Delta Q = \Delta u + \Delta W$$

For isothermal process $\Delta u = 0$

$$\therefore \quad \Delta W = \Delta Q = -730 \text{ J}$$

(–ve, because work is done on the gas)

$\therefore$ Change in entropy Δs

$$= \frac{\Delta Q}{T} = \frac{-730}{(27+273)} = -2{\cdot}43 \text{ J/K}$$

2. Since, the gas is heated at constant volume, so

$$\frac{P}{P_0} = \frac{T}{T_0}$$

Again $P = 2P_0$

$$\therefore \quad T = 2T_0$$

Hence, change of temperature of the gas is

$$\Delta T = T - T_0 = T_0 = 273 \text{ K}$$

$$\therefore \quad \Delta Q = \mu C_V \Delta T = 0{\cdot}5 \times 12{\cdot}4 \times 273 = 1693 \text{ J}$$

3. From Wien's displacement law,

$$\lambda_m T = \text{constant}$$

$\therefore \lambda_m T$ for filament $= \lambda_m T$ for sun

$$2T = 0{\cdot}5 \times 6000$$

$$\Rightarrow \quad T = 1500 \text{ K}$$

4. Average kinetic energy per molecule of oxygen is

$$\frac{1}{2} m v^2_{rms} = \frac{3}{2} kT$$

$$v_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3kTN_A}{32}}$$

($N_A \rightarrow$ Avogadro's no.)

Similarly for hydrogen

$$v_{rms} = \sqrt{\frac{3kT_1N_A}{2}}$$

Equating

$$\frac{T_1}{2} = \frac{T}{32}$$

$$\Rightarrow \quad T_1 = \frac{(47+273)}{16} = 20\text{K}$$

5. The self inductance of the coil is

$$L = \mu_0 N^2 \frac{A}{d} = 4\pi \times 10^{-7} \times (200)^2 \times \frac{3{\cdot}14 \times (10^{-2})^2}{0{\cdot}30}$$

$$= \frac{4 \times 4 \times (3{\cdot}14)^2}{3} \times 10^{-5} = 5{\cdot}26 \times 10^{-4} \text{ H}$$

$$U = \frac{1}{2} L i^2 = \frac{1}{2} \times 5{\cdot}26 \times 10^{-4} \times 3^2 = 2{\cdot}37 \times 10^{-3} \text{ J}$$

6. If the e.m.f. of the cells are E_1 and E_2 respectively, then

$$\frac{E_1 + E_2}{E_1 - E_2} = \frac{60}{12}$$

$$\Rightarrow \frac{(E_1 + E_2) + (E_1 - E_2)}{(E_1 + E_2) - (E_1 - E_2)} = \frac{60 + 12}{60 - 12}$$

$$\Rightarrow \quad \frac{E_1}{E_2} = \frac{72}{48} = \frac{3}{2}$$

7. **Distinct vision**

For eye-piece

$$\frac{1}{u_1} + \frac{1}{-D} = \frac{1}{f_e}$$

$$\frac{1}{u_1} = \frac{1}{5} - \frac{1}{-30}$$

$$\Rightarrow \quad u_1 = \frac{30}{7} = 4{\cdot}3 \text{ cm}$$

Separation $= f_0 + u_1 = 20 + 4{\cdot}3 = 24{\cdot}3$ cm

Normal vision

Separation $= f_0 + f_e = 20 + 5 = 25$ cm

8. ${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{38}Sr^{90} + {}_{54}Xe^{143} + 3{}_0n^1$

9. Let $\vec{A} = \hat{i} + 3\hat{j} + 5\hat{k}$

$$\vec{B} = 2\hat{i} + 6\hat{j} + 10\hat{k}$$

Then $\vec{B} = 2\vec{A}$

Now, $\vec{A} \times \vec{B} = \vec{A} \times 2\vec{A} = 2(\vec{A} \times \vec{A}) = 0$

Hence, $\vec{A}$ and $\vec{B}$ are parallel.

12. Hydrogen atom in the ground state will only absorb energy greater than 10·2 eV. If this occurs the collision will be inelastic. If there is no absorption of energy, the collision is elastic.

13. $$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$\omega L - \frac{1}{\omega C} = 2\pi f L - \frac{1}{2\pi f C} = 2 \times 3{\cdot}14 \times 50 \times 0{\cdot}5 - \frac{10^6}{2 \times 3{\cdot}14 \times 50 \times 15} = -55{\cdot}31$$

$$\left(\omega L - \frac{1}{\omega C}\right)^2 = (-55{\cdot}31)^2 = 3059$$

$$\therefore \quad Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} = \sqrt{(100)^2 + 3059} \simeq 114{\cdot}3$$

$$I_V = \frac{E_V}{Z} = \frac{200}{114{\cdot}3} = 1{\cdot}75 \text{ A}$$

Power factor $= \cos\phi = \frac{R}{Z} = \frac{100}{114{\cdot}3} = 0{\cdot}8759$

14. From conservation of energy

$$\frac{1}{2} L i^2_{max} = \frac{1}{2} C V^2_{max}$$

or, $$i_{max} = \sqrt{\frac{C}{L}} \cdot V_{max} = 150 \sqrt{\frac{16 \times 10^{-6}}{0{\cdot}04}} = 3\text{A}$$

15. In case of the vibration of a string, both even and odd harmonics are obtained. That is, frequencies are n, $2n$, $3n$, $4n$ etc. The difference between the two consecutive frequencies gives the fundamental frequency. In the present case,

$$n = 490 - 420 = 70 \text{ Hz.}$$

$$n = \frac{1}{2l} \sqrt{\frac{T}{m}}$$

$$\Rightarrow \quad l = \frac{1}{2n} \sqrt{\frac{T}{m}} = \frac{1}{2 \times 70} \sqrt{\frac{4{\cdot}5}{5 \times 10^{-3}}} = \frac{3}{14} \text{ m}$$

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KINETIC THEORY, GAS LAWS AND SPECIFIC HEAT OF GASES

- Pressure exerted by the gas $P = \frac{1}{3}\frac{mn}{V}\overline{c^2}$
- Root Mean Square Velocity

$$\bar{c} = \sqrt{\frac{c_1^2 + c_2^2 + c_3^2 + ... + c_n^2}{n}} = \sqrt{\frac{3RT}{M}}$$

- Average velocity of molecules

$$c = 0{\cdot}921\ \bar{c}$$

- Maximum velocity of molecules

$$c_{max} = 0{\cdot}817\ \bar{c}$$

- Dependence of $\bar{c}$ on absolute temperature $\bar{c} \propto \sqrt{T}$
- Dependence of $\bar{c}$ on molecular weight $\bar{c} \propto \sqrt{\frac{1}{M}}$
- Boyle's law $P \propto \frac{1}{V}$
- Charle's law $V \propto T$
- Gas equation $PV = RT$
- Graham's law of diffusion $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$
- For monoatomic gases
  (i) $c_v = 3$ cal mole^{-1} °C^{-1}
  (ii) $c_p = 5$ cal mole^{-1} °C^{-1}
- For diatomic gases
  (i) $c_v = 5$ cal mole^{-1} °C^{-1}
  (ii) $c_p = 7$ cal mole^{-1} °C^{-1}
- In all cases, for 1 mole
  $c_p - c_v = 2$ cal mol^{-1} °C^{-1} = R (approx.)
- For monoatomic gases $\gamma = \frac{c_p}{c_v} = \frac{5}{3}$
- For diatomic gases $\gamma = \frac{c_p}{c_v} = \frac{7}{5}$
- For triatomic gases $\gamma = \frac{c_p}{c_v} = \frac{4}{3}$

OBJECTIVE QUESTIONS

1. The energy of a gas per litre is 300 joules. Its pressure will be—
   (A) 3×10^5 N/m^2
   (B) 6×10^5 N/m^2
   (C) 10^5 N/m^2
   (D) 2×10^5 N/m^2

2. N molecules each of mass m of gas A and 2N molecules each of mass $2m$ of gas B are contained in the same vessel at temperature T. The mean square of the velocity of molecules of gas B is v^2 and the mean squares of x component of the velocity of molecules of gas A is w^2. The ratio $\frac{w^2}{v^2}$ is—
   (A) 1 (B) 2
   (C) 1/3 (D) 2/3

3. If the universal gas constant is 8·3 joule mole^{-1} K^{-1} and the Avogadro's number 6×10^{23}. The mean kinetic energy of the oxygen molecules at 327°C will be—
   (A) 415×10^{-23} joule
   (B) 2490×10^{-22} joule
   (C) 1245×10^{-23} joule
   (D) 830×10^{-22} joule

4. The temperature of a gas at pressure P and volume V is 27°C. Keeping its volume constant, if its temperature is raised to 927°C, then its pressure will be—
   (A) 2P (B) 3P
   (C) 4P (D) 6P

5. At constant pressure, the temperature of 56 gm of nitrogen is raised by 5°C. If the value of universal gas constant is 8·3 joule mole^{-1} K^{-1}, then the work done by the gas will be—
   (A) 8·3 joule
   (B) 41·5 joule
   (C) 83 joule
   (D) None of the above

6. The respective speeds of five molecules are 2, 1·5, 1·6, 1·6 and 1·2 km/sec. The most probable speed in km/sec will be—
   (A) 2 (B) 1·58
   (C) 1·6 (D) 1·31

7. If one mole of a monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with one mole of diatomic gas $\left(\gamma = \frac{7}{5}\right)$, the value of γ for the mixture is—
   (A) 1·40 (B) 1·50
   (C) 1·53 (D) 3·07

8. If the degrees of freedoms of a gas are f, then the ratio of two specific heats $\frac{c_p}{c_v}$ is given by—
   (A) $\frac{2}{f} + 1$ (B) $1 - \frac{2}{f}$
   (C) $1 + \frac{1}{f}$ (D) $1 - \frac{1}{f}$

9. For a certain gas, the ratio of specific heats is given to be $\gamma = 1{\cdot}5$. For this gas—
   (A) $c_v = \frac{3R}{J}$ (B) $c_p = \frac{3R}{J}$
   (C) $c_p = \frac{5R}{J}$ (D) $c_v = \frac{5R}{J}$

10. The root mean square speed of hydrogen molecule of an ideal hydrogen gas kept in a gas chamber at 0°C is 3180 metre/second. The pressure on the hydrogen gas is— (density of hydrogen gas is $8{\cdot}99 \times 10^{-2}$ kg/

m^3, 1 atmosphere = $1{\cdot}01 \times 10^5$ N/m^2)

(A) 1·0 atmosphere

(B) 1·5 atmosphere

(C) 2·0 atmosphere

(D) 3·0 atmosphere

11. One mole of an ideal gas expands at a constant temperature of 300 K from an initial volume of 10 litres to a final volume of 20 litres. The work done in expanding the gas is—

($R = 8{\cdot}31$ J $mole^{-1}$ K^{-1})

(A) 750 joule

(B) 1726 joule

(C) 1500 joule

(D) 3456 joule

12. The specific heat of hydrogen gas at constant pressure is $c_p = 3{\cdot}4 \times 10^3$ cal/kg°C and at constant volume is $c_v = 2{\cdot}4 \times 10^3$ cal/kg°C. If one kilogram hydrogen gas is heated from 10°C to 20°C at constant pressure, the external work done on the gas to maintain it at constant pressure is—

(A) 10^3 calorie

(B) 5×10^3 calorie

(C) 10^4 calorie

(D) 10^5 calorie

13. The temperature of the hydrogen at which the average speed of its molecules is equal to that of oxygen molecules at a temperature of 31°C is—

(A) −216°C (B) −235°C

(C) −254°C (D) −264°C

14. Calculate the average kinetic energy of a gas molecule at a temperature of 300 K.

(The Boltzmann's constant $k = 1{\cdot}38 \times 10^{-23}$ JK^{-1})

(A) $6{\cdot}21 \times 10^{-21}$ J

(B) $62{\cdot}1 \times 10^{-21}$ J

(C) $6{\cdot}21 \times 10^{-23}$ J

(D) $26{\cdot}1 \times 10^{-23}$ J

15. At what temperature would the rms speed of a gas molecule have twice its vlaue at 100°C—

(A) 4192 K (B) 1492 K

(C) 9142 K (D) 2491 K

16. Find the rms speed of an argon molecule at 27°C. (Molecular weight of argon = 40 gm/mole)

(A) 234·2 m/s

(B) 342·2 m/s

(C) 432·2 m/s

(D) 243·2 m/s

ANSWERS

1. (D) 2. (D) 3. (C) 4. (C) 5. (C) 6. (D) 7. (B) 8. (A) 9. (B) 10. (D) 11. (B) 12. (C) 13. (C) 14. (A) 15. (B) 16. (C)

HINTS

1. Energy = 300 J/litre

$= 300 \times 10^3$ J/m^3

$P = \frac{2}{3}E = \frac{2 \times 300 \times 10^3}{3}$

$= 2 \times 10^5$ N/m^2

2. $3w^2 = \frac{3RT}{m}$ $\quad [\because v^2_{max} = 3v_x^2 = 3w^2]$

and $v^2 = \frac{3RT}{2m}$

$\Rightarrow \frac{w^2}{v^2} = \frac{2}{3}$

3. Mean K. E. $= \frac{3}{2}\frac{R}{N}T$

$= \frac{3}{2} \times \frac{8{\cdot}3}{6 \times 10^{23}} \times 600$

$= 1245 \times 10^{-23}$ J

4. Using Charle's law

$\frac{P_1}{P_2} = \frac{T_1}{T_2}$

$\Rightarrow P_2 = \frac{T_2}{T_1} \times P = \frac{(927 + 273)}{(27 + 273)} \times P$

$= \frac{1200\,P}{300} = 4P$

5. For n moles of a gas n have $PV = nRT$

The work done by the gas $W = PdV = nRdT$

$= \frac{56}{28} \times 8{\cdot}3 \times 5$

$= 83$ J

6. Most probable speed

$= 0{\cdot}817\,\bar{c}$

$= 0{\cdot}817\sqrt{\frac{2^2 + 1{\cdot}5^2 + 1{\cdot}6^2 + 1{\cdot}6^2 + 1{\cdot}2^2}{5}}$

$= 1{\cdot}31$

7. $\gamma = \frac{n_1 c_{p_1} + n_2 c_{p_2}}{n_1 c_{v_1} + n_2 c_{v_2}}$

$= \frac{\frac{5}{2} + \frac{7}{2}}{\frac{3}{2} + \frac{5}{2}} = 1{\cdot}5$

9. $\frac{c_p}{c_v} = 1{\cdot}5$

$\Rightarrow c_v = \frac{c_p}{1{\cdot}5}$

Also $c_p - c_v = \frac{R}{J}$

or, $c_p - \frac{c_p}{1{\cdot}5} = \frac{R}{J}$

or, $\frac{0{\cdot}5\,c_p}{1{\cdot}5} = \frac{R}{J}$

$\Rightarrow c_p = \frac{3R}{J}$

10. $v = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{M}}$

$= \sqrt{\frac{3P}{M/V}} = \sqrt{\frac{3P}{d}}$

$$\Rightarrow \quad 3180 = \sqrt{\frac{3P}{8.99 \times 10^{-2}}}$$

$$\Rightarrow \quad P = 303034.9 \text{ N/m}^2$$

$$= 3 \text{ atmosphere}$$

($\because$ 1 atmosphere = 1.01×10^5 N/m^2)

11. At constant temperature,

$$PV = \text{constant}$$

$$P_1 \times 10 = P_2 \times 20$$

$$\Rightarrow \quad P_2 = \frac{P_1}{2}$$

$$W = \int P dV$$

$$= \int RT \frac{dV}{V} = RT \int_{V_1}^{V_2} \frac{dV}{V}$$

$$= RT [\log V]_{V_1}^{V_2}$$

$$= RT \log \frac{V_2}{V_1}$$

$$= RT \log \frac{20}{10}$$

$$= RT \log_e 2$$

$$= 8.31 \times 300 \times \log_e 2 = 1726 \text{ joule}$$

12. $$Q = mc_p dT$$

$$= 1 \times 3.4 \times 10^3 \times 10$$

$$= 3.4 \times 10^4 \text{ cal}$$

$$dU = m c_v dT$$

$$= 2.4 \times 10^4 \text{ cal}$$

But $Q = W + dU$

$\Rightarrow \quad W = Q - dU$

$$= 1 \times 10^4 \text{ cal}$$

13. $v_{rms} \times 0.921 = v_{average}$

or, $v_{average} \propto v_{rms}$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

For hydrogen

$$v_{rms}(H) = \sqrt{\frac{3RT}{2}}$$

For oxygen

$$v_{rms}(O) = \sqrt{\frac{3R(273+31)}{32}}$$

Given, $\sqrt{\frac{3RT}{2}} = \sqrt{\frac{3R \times 304}{32}}$

$$T = \frac{304}{16} = 19 \text{ K}$$

$$= (19 - 273)^\circ C = -254^\circ C$$

14. The average kinetic energy per molecule is

$$E_k = \frac{3}{2} kT$$

$$= \frac{3}{2} \times 1.38 \times 10^{-23} \times 300$$

$$= 6.21 \times 10^{-21} \text{ J}$$

15. $$\bar{c}_1^2 = \frac{3kT_1}{m}$$

$$\bar{c}_2^2 = \frac{3kT_2}{m}$$

Given $\bar{c}_2 = 2\bar{c}_1$

or, $\bar{c}_2^2 = 4\bar{c}_1^2$

$$\frac{3kT_2}{m} = 4 \cdot \frac{3k \times (273+100)}{m}$$

$\Rightarrow \quad T_2 = 1492 \text{ K}$

16. Root mean square speed is given by

$$\bar{c} = \sqrt{\frac{3RT}{M}}$$

$$= \sqrt{\frac{3 \times 8.3 \times (273+27)}{40 \times 10^{-3}}}$$

$$= \sqrt{\frac{3 \times 8.3 \times 300}{40 \times 10^{-3}}}$$

$$= 432.2 \text{ m/s}$$

●●●

At a Glance

BEVERAGES

Common name	Botanical name	Family	Characteristics
Non-Alcoholic			
Coffee	*Coffea arabica*	Rubiaceae	Dried seeds roasted, ground and brewed to make stimulating beverage.
Cocoa	*Theobroma cacoas*	Sterculiaceae	Dried seeds used as non-alcoholic beverage and also used for making chocolates.
Tea	*Thea sinensis*	Theaceae	Young leaves and shoot tips are processed to prepare tea.
Alcoholic			
Beer	*Hordeum vulgare*	Gramineae	Barley malt used, 3–6% alcohol
Brandy (from grapes)	*Vitis vinifera*	Vitaceae	Fermented and distilled juice, 60–70% alcohol
Rum (from molasses)	*Saccharum officinarum*	Gramineae	40% alcohol
Whisky (cereals potatoes)		Gramineae & solanaceae	Distilled alcohol, 50% alcohol

ALKALINE EARTH METALS : GROUP II A

Introduction :

The term alkaline earth metals is generic name for the chemical elements **beryllium** (Be), **magnesium** (Mg), **calcium** (Ca), **strontium** (Sr), **barium** (Ba), and **radium** (Ra), which are the members of group II A of the periodic table of the elements. Prior to the 19th century, substances that were non-metallic, insoluble in water and unchanged by fire were known as earths. Those earths like lime, that resembled the alkalies were designated alkaline earths. Alkaline earths were, thus distinguished from the alkalies and from other earths, such as **alumina** and the **rare earths**. By the first decade of 19th century it became clear that the earths, formerly considered to be elements, were in fact oxides, compounds of metals and oxygen. The metals whose oxides make up the **alkaline earths** then came to be known as the alkaline earth metals.

History :

The earliest known alkaline earth was lime (Latin-calx) which is now known as calcium oxide; it was used in ancient times in the composition of mortar. Magnesia, the oxide of magnesium was shown to be an alkaline earth different from lime by the **Scottish chemist Joseph Black** in 1755; he observed that magnesia give rise to be a soluble sulphate, whereas that derived from lime was known to be insoluble. In 1774 **Carl Wilhelm Scheele**, the Swedish chemist who discovered oxygen, found that the mineral called heavy spar or barys (Greek-heavy) contained a new earth, which became known as **baryta** (barium oxide). A further earth, strontia (strontium oxide), was identified by **Adair Crawford**, a London physician and chemist, in 1790 on examining a mineral (strontium carbonate) found in a lead mine at strontium in Argyllshride, Scotland. Beryllia (Beryllium oxide) was extracted from the mineral beryl and recognized as an earth by the **French** analytical chemist **Louis Nicolas** in 1797. Beryllia was originally called **glucina** (Greek glykys, sweet) because of its sweet taste. On the same basis the element beryllium was first named as **glucinium**. In 1798 **Vauquelin** prepared Be in the pure form.

Magnesium, calcium, strontium and barium, elements derived from alkaline earths, were isolated as impure metals by the English chemist Sir Humphry Davy in 1808, by means of the electrolytic method he had previously applied for the isolation of the alkali metals, potassium and sodium. Barium was first isolated by the German chemist **Friedrich Wohler** in 1828. Radium was discovered in 1898 by means of its radioactivity by **Pierre** and **Marie Curie**, who separated it with great difficulty from barium.

Electronic Structure :

Element	Symbol	Electronic Structure	
Beryllium	Be	$1s^2\,2s^2$	or [He] $2s^2$
Magnesium	Mg	$1s^2\,2s^2\,2p^6\,3s^2$	or [Ne] $3s^2$
Calcium	Ca	$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2$	or [Ar] $4s^2$
Strontium	Sr	$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,5s^2$	or [Kr] $5s^2$
Barium	Ba	$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,5s^2\,5p^6\,6s^2$	or [Xe] $6s^2$
Radium	Ra		[Rn] $7s^2$

All group IIA elements have two s electrons in their outermost shell. Ignoring the filled inner orbitals, their electronic structures may be written $2s^2$, $3s^2$, $4s^2$, $5s^2$, $6s^2$ and $7s^2$.

Occurrence and Abundance :

The abundance of elements in the earth crust by weight is given as :

Symbol	ppm	Relative abundance
Be	2·00	51
Mg	27,640	6
Ca	46,600	5
Sr	384	15
Ba	390	14
Ra	$1{\cdot}3 \times 10^{-6}$	—

Beryllium—It is not very familiar, partly because it is not very abundant (2ppm) and partly because it is difficult to extract. It is found in small quantities as the silicate minerals beryl ($Be_3Al_2Si_6O_{18}$) and phenacite, Be_2SiO_4. The **gemstone emerald** has same formula as beryl, but also contains small amounts of chromium which make it green in colour.

Magnesium—It is the sixth most abundant element in the earths crust. Magnesium salts occur to about 0·13% in sea water. Entire mountain ranges (example, the Dolomite in Italy) consist of the mineral **dolomite** [$MgCO_3{\cdot}CaCO_3$]. There are also large deposits of **magnesite** [$MgCO_3$]. There are also deposits of sulphates such as **epsomite** [$MgSO_4{\cdot}7H_2O$] and **kieserite** [$MgSO_4{\cdot}H_2O$]. **Carnallite** [$KCl{\cdot}MgCl_2{\cdot}6H_2O$] is mined as a source of potassium. Magnesium also occurs in wide range silicate minerals including **olivine** [$(Mg, Fe)_2SiO_4$], **talc** [$Mg_3(OH)_2Si_4O_{10}$], **chrysolite** [$Mg_3(OH)_4Si_2O_5$] and **micas** such as $K^+[Mg_3(OH)_2{\cdot}(AlSi_3O_{10})^-$.

Calcium—It is the fifth most abundant element in the earth's crust and it occurs throughout the world in many common minerals. There are vast sedimentary deposits of $CaCO_3$ existing as whole mountain ranges of limestone,

marble, and chalk. These are originated from the shells of marine life. There are two crystalline forms of $CaCO_3$, **calcite** and **aragonite**. Calcite is more common : it forms colourless rhombohedral crystals. Aragonite is orthorhombic and is commonly red-brown or yellow in colour.

Fluoroapatite $[3(Ca_3(PO_4)_2).CaF_2]$ is commercially important source of phosphate. Gypsum $[CaSO_4 \cdot 2H_2O]$ and anhydrite $CaSO_4$ are major minerals. Fluorite is an important source of fluorine.

Strontium and Barium—Strontium and barium are much less abundant, but are well known because they occur as concentrated ores which are easy to extract. Strontium is mined as **celestite,** $SrSO_4$ and **strontianite** $SrCO_3$. Barium is mined as **barytes**, $BaSO_4$.

Radium—Radium is extremely scarce and is radioactive. It was first isolated by **Pierre** and **Marie Curie** by processing many tons of the uranium ore, **pitchblende**. **Marie Curie** was awarded the Nobel Prize for chemistry in 1911 for isolating and studying **radium** and **polonium**.

General Physical Properties :

The alkaline earth elements are highly metallic and are good conductors of electricity. They have grey-white lustre when freshly cut but tarnish readily in air, particularly the heavier members of the group. Beryllium is sufficiently hard to scratch the glass, but barium is only slightly harder than lead. Some important physical properties of alkaline earth metals are given in the following table :

Some Properties of the Alkaline Earth Metals

	Beryllium	Magnesium	Calcium	Strontium	Barium	Radium
Atomic number	4	12	20	38	56	88
Atomic weight (Stablest isotope)	9·0122	24·312	40·08	87·62	137·34	(226)
Colour of element	grey	silvery white	silvery white	silvery white	silvery white	silvery white
Melting point (°C)	1,283	650	842–48	769	725	700
Boiling point (°C)	~ 2,500	1,105	1,487	1,384	1,140	< 1,737
Density at 20° C (g /cm^3)	1·85	1·74 (5° C)	1·54	2·54	3·51	(about 5)
Oxidation number	2	2	2	2	2	2
Electronic configuration	$1s^2\,2s^2$	(Ne) $3s^2$	(Ar) $4s^2$	(Kr) $5s^2$	(Xe) $6s^2$	(Rn) $7s^2$
Isotopic abundance (terrestrial, percent)	^{9}Be (100)	^{24}Mg (78·70), ^{25}Mg (10·13), ^{26}Mg (11·17),	^{40}Ca (96·97) ^{42}Ca (0·64), ^{43}Ca (0·145), ^{44}Ca (2·06), ^{46}Ca (0·0033), ^{48}Ca (0·18)	^{84}Sr (0·56), ^{86}Sr (9·86), ^{87}Sr (7·02), ^{88}Sr (82·56)	^{130}Ba (0·101), ^{132}Ba (0·097), ^{134}Ba (2·42), ^{135}Ba (6·59), ^{136}Ba (7·81), ^{137}Ba (11·32), ^{138}Ba (71·66)	—
Radioactive isotopes (mass numbers)	7, 10 – 11	20 – 23, 27 – 28	37 – 39, 41 45, 47, 49, 50	80 – 83, 85 89 – 93 95	123, 125 – 29, 131, 133, 139 – 43	213 – 17, 219 – 30
Electrical resistivity at 0° C (microhm-cm)	4·0	4·45	3·91	23	80	—
Crystal structure*	HCP	HCP	FCC, HCP, BCC	FCC, HCP, BCC	BCC	—
Radius ionic M^{2+} (Å)	0·31	0·65	0·99	1·13	1·35	1·40
Diameter, atomic (Å) (co-ordination number of 12)	2·25	3·20	3·93	4·30	4·48	—
Ionization energy (electron volt)						
First	9·32	7·64	6·11	5·69	5·21	5·28
Second	18·21	15·03	11·87	11·03	10·00	10·14
Third	153·85	80·12	51·21	—	—	—
Electrode potential (according to international convention) $M^{2+} + 2e^- \rightarrow M$, at 25°C, volt	– 1·85	– 2·37	– 2·87	– 2·89	– 2·91	– 2·92
Electronegativity (Pauling)	– 1·5	– 1·2	– 1·0	– 1·0	– 0·9	– 0·9

* HCP = hexagonal close packed, FCC = face-centred cubic (cubic close packed), BCC = body-centred cubic.

(A) **Size of Atoms and Ions**—Group-II atoms are large, but are smaller than the corresponding Group-I elements as the extra charge on the nucleus draws the orbital electrons in. Similarly the ions are large, but are smaller than those of Group-I, specially because the removal of two orbital electrons increases the effective nuclear charge even further. Thus these elements have higher densities than Group-I metals.

	Metallic radius Å	Ionic radius M^{2+} six-coordinate Å	Density (gm/cm^3)
Be	1·12	0·31	1·85
Mg	1·60	0·72	1·74
Ca	1·97	1·00	1·55
Sr	2·15	1·18	2·63
Ba	2·22	1·35	3·62
Ra		1·48	5·5

Group-II metals are silvery white in colour. They have two valency electrons which may participate in metallic bonding, compared with one electron for Group-I metals. Consequently, Group-II metals are harder, have higher cohesive energy, and have much higher melting points and boiling points than Group-I elements.

(B) **Ionization Energy**—The third ionization energy is so high that M^{3+} ions are never formed. The ionization energy of Be^{2+} is high and its compounds are typically covalent. Magnesium also forms some covalent compounds. Since, the atoms are smaller than those in Group-I, the electrons are more tightly held so that the energy needed to remove the first electrons is greater than for Group-I. Once one electron has been removed, the ratio of charges on nucleus to orbital electrons is increased so that the remaining electrons are more tightly held. Hence, the energy required to remove second electron is nearly double that required for the first one. The total energy required to produce gaseous divalent ions for Group-II elements is over four times greater than the energy required to produce M^+ ions from Group-I metals.

(C) **Hydration-Energy**—The hydration energy of the Group-II ions is four times greater than Group-I ions. This is largely due to their smaller size and increased charge, and $\Delta_{hydration}$ decreases down the group as the size of the ions increases. In the case of Be a further factor is the very strong complex $[Be(H_2O)_4]^{2+}$ that is formed. The crystalline compounds of Group-II contain more water of crystallization than the corresponding Group-I compounds. Thus NaCl, KCl are anhydrous but $MgCl_2 \cdot 6H_2O$, $CaCl_2 \cdot 6H_2O$ and $BaCl_2 \cdot 2H_2O$ all have water of crystallization. Remember that the number of molecules of water of crystallization decreases as the ions become larger. Since, divalent ions have noble gas structure with no unpaired electrons, their compounds are diamagnetic and colourless.

Hydration Energies

	Ionic radius (Å)	ΔH Hydration (kJ/mol.)
Be^{2+}	0·31	– 2494
Mg^{2+}	0·72	– 1921
Ca^{2+}	1·00	– 1575
Sr^{2+}	1·18	– 1443
Ba^{2+}	1·35	– 1305

(D) **Solubility and Lattice Energy**—The solubility of most of the salts decreases with increased atomic weight, though the usual trend is reversed with fluorides and hydroxides in this group. Solubility of salts depends on the lattice energy of the salt, and the hydration of energy of the ions. The lattice energy values for Group-II compounds are much higher than the values for Group-I compounds, because of the effect of the increased charge on the ions. For any particular negative ion, the lattice energy decreases as the size of the metal increases.

Lattice energies of some compounds (kJ mol^{-1})

	MO	MCO_3	MF_2	MI_2
Mg	– 3923	– 3178	– 2906	– 2292
Ca	– 3517	– 2986	– 2610	– 2058
Sr	– 3312	– 2718	– 2459	—
Ba	– 3120	– 2614	– 2367	—

The hydration energy also decreases as the metal ions become larger. For a salt to dissolve, the hydration energy must exceed the lattice energy. On descending the group the metal ions become larger and so both lattice energy and hydration energy decrease. **A decrease in lattice energy favours increased solubility but decrease in hydration energy favours decreased solubility.**

The two factors thus brings about change in opposite directions and the overall effect depends on which of the two has changed the most. With most compounds, on descending the group, the hydration energy decreases more rapidly than the lattice energy, hence the compounds become less soluble as the metal gets larger. However, with fluorides and hydroxides the lattice energy decreases more rapidly than the hydration energy, and so their solubility increases on descending the group.

Solution of Metals in Liquid Ammonia :

These metals all dissolve in liquid ammonia as do the Group-I metals. Dilute solutions are bright blue in colour due to the solvated electron. These solutions decompose very slowly, forming amides and evolving hydrogen, but the reaction is accelerated by many transition metals and their compounds

$$2NH_3 + 2e \rightarrow 2NH_2^- + H_2$$

Evaporation of the ammonia from solutions of Group-I metals yields the metals, but with Group-II metals evaporation of ammonia gives hexammoniates of the metals. These slowly decompose to give amides.

$$M(NH_3)_6 \rightarrow M(NH_2)_2 + 4NH_3 + H_2$$

Concentrated solutions of the metals are bronze coloured due to the formation of metal clusters.

Chemical Properties :

Some important chemical reactions of Group-II elements are listed in the following table :

Reaction	Comment
$M + 2H_2O \rightarrow M(OH)_2 + H_2$	Be probably reacts with steam, Mg with hot water, and Ca, Sr and Ba react rapidly with cold water
$M + 2HCl \rightarrow MCl_2 + H_2$	All the metals with acids, liberating hydrogen
$Be + NaOH \rightarrow Na_2[Be(OH)_4] + H_2$ Or $Na_2BeO_2 \cdot 2H_2O + H_2$	Be is amphoteric
$2M + O_2 \rightarrow 2MO$	Normal oxide formed by all group members
with excess dioxygen	
$Ba + O_2 \rightarrow BaO_2$	Ba also forms the peroxide
$M + H_2 \rightarrow MH_2$	Ionic 'salt-like' hydrides formed at high temperatures by Ca, Sr and Ba
$3M + N_2 \rightarrow M_3N_2$	All form nitrides at high temperatures
$3M + 2P \rightarrow M_3P_2$	All the metals form phosphides at high temperatures
$M + S \rightarrow MS$	All the metals form sulphides
$M + Se \rightarrow MSe$	All the metals form selenides
$M + Te \rightarrow MTe$	All the metals form tellurides
$M + F_2 \rightarrow MF_2$	All the metals form fluorides
$M + Cl_2 \rightarrow MCl_2$	All the metals form chlorides
$M + Br_2 \rightarrow MBr_2$	All the metals form bromides
$M + I_2 \rightarrow MI_2$	All the metals form iodides
$3M + 2NH_3 \rightarrow 2M(NH_2)_2$	All the metals form amides at high temperatures

Compounds of alkaline earth Elements and Gradation in their Properties :

Hydroxides and Carbonates—The reduction potential of beryllium is much less than that for the rest of elements of the Group-II.

Standard electrode potentials, E° for different elements are as—

$Be^{2+}/Be = -1{\cdot}85V$
$Mg^{2+}/Mg = -2{\cdot}37V$
$Ca^{2+}/Ca = -2{\cdot}87V$
$Sr^{2+}/Sr = -2{\cdot}89V$
$Ba^{2+}/Ba = -2{\cdot}91V$
$Ra^{2+}/Ra = -2{\cdot}92V$

This indicates that Be is much less electropositive than others, and Be does not react with water. Ca, Sr, Ba have reduction potentials similar to those of the corresponding Group-I elements, and are reasonably high in the electrochemical series. They react with cold water quite readily, liberating hydrogen and forming metal hydroxides.

$$M + 2H_2O \rightarrow M(OH)_2 + H_2$$

Magnesium does not react with cold water, however, it decomposes hot water.

$$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$$

Magnesium forms a protective layer of oxide, so despite its favourable reduction potential, it does not react readily unless the oxide layer is removed by amalgamating with mercury.

$$Mg + H_2O \rightarrow MgO + H_2$$

$Be(OH)_2$ is amphoteric, but hydroxides of Mg, Ca, Sr and Ba are basic. The basic strength increases as

$$Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$$

The same is the order of solubility of hydroxides. The solutions of $Ca(OH)_2$ and $Ba(OH)_2$ are called **lime water** and **baryta water** respectively.

When CO_2 is passed through these solutions, they become turbid or milky due to the formation of a suspension of solid $CaCO_3$ or $BaCO_3$. If excess of CO_2 is passed through these milky solutions then the turbidity disappears as soluble bicarbonates are formed.

$$Ca(OH)_2 + CO_2 \rightarrow \underset{\text{Insoluble white turbidity}}{CaCO_3} + H_2O \xrightarrow[\text{Excess}]{CO_2} \underset{\text{Soluble}}{Ca(HCO_3)_2}$$

The bicarbonates of Group-II metals are only stable in solution. Caves in limestone regions often have **stalactites** growing down from the roof, and **stalagmites** growing up from the roof. Water percolating through the limestone contains some $Ca(HCO_3)_2$ in solution. The soluble bicarbonate decomposes slowly into insoluble carbonate and this results in the slow growth of **stalactites** and **stalagmites**.

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + CO_2 + H_2O$$

The stability of carbonates increases on moving down the group. This is illustrated by the temperature at which the carbonates decompose.

$BeCO_3$: 100°C, $MgCO_3$: 540°C, $CaCO_3$: 900°C

$SrCO_3$: 1290°C, $BaCO_3$: 1360°C.

Oxides and Peroxides—All the elements of this group burn in O_2 to form oxides MO. Be metal is relatively unreactive in the massive form and does not react below 600°C, but the powder is much more reactive and burns brilliantly. The elements also burn in air, forming a mixture of oxide and nitride. Mg burns with dazzling brilliance in air, and evolves a lot of heat. This is used to start a thermite reaction with aluminium, and also to provide light in flash photography.

$$4Mg + air \rightarrow MgO + Mg_3N_2$$

Calcium oxide (quicklime) is made in enormous quantities by roasting $CaCO_3$ in a lime kiln.

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$$

The oxides of alkaline earth elements have a number of properties that make them useful for lining furnaces.

(a) They have very high melting points.

(b) They have low vapour pressures.

(c) They are very good conductors of heat.

(d) They are chemically inert.

(e) They act as electrical insulators.

Beryllium oxide is a very hard solid. It can scratch even quartz. BeO has a **wurtzite structure** with 4 : 4 co-ordination while rest of the oxides have NaCl type lattices with 6 : 6 co-ordination. The oxides are highly stable due to large ionic crystal lattice energies. The values are so high in the case of oxides of Be and Mg that these compounds are almost insoluble in water. The oxides of the rest of the elements react with water to yield hydroxides which are basic in character. BeO is **amphoteric**, while other oxides are basic in character.

Peroxides are formed with increasing ease and increasing stability as the metal ions become larger. Barium peroxide (BaO_2) is formed by passing air over BaO at 500°C. SrO_2 can be formed in the similar way but it requires a high pressure and temperature. CaO_2 is not formed in this way but can be made as a hydrate by treating $Ca(OH)_2$ with H_2O_2 and then dehydrating the product. Crude MgO_2 is made by using H_2O_2 but no peroxide of Be is known.

Points to Remember

- Lime (CaO) is used in steel making to remove phosphates and silicates as slag.
- In making cement lime is used with SiO_2 and Al_2O_3 or clay.
- Lime plays important role in preparation of glass.
- In the lime-soda process, which is part of the chlor-alkali industry, lime is used for converting Na_2CO_3 to NaOH or vice-versa.
- Lime on reacting with water forms slaked lime, $Ca(OH)_2$.
- Bleaching powder is made by passing Cl_2 into slaked lime. Though bleaching powder is often written as $Ca(OCl)_2$, it is really a mixture.

  $3Ca(OH)_2 + 2Cl_2 \rightarrow Ca(OCl)_2 \cdot Ca(OH)_2 \cdot CaCl_2 \cdot 2H_2O$
- Soda-lime is a mixture of NaOH and $Ca(OH)_2$ and is made from quick-lime (CaO) and aqueous NaOH.

Sulphates—The solubility of the sulphates in water decreases down the group.

$BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4 > RaSO_4$

The significantly high solubility of $BeSO_4$ and $MgSO_4$ is due to the high enthalpy of solvation of the smaller Be^{2+} and Mg^{2+} ions.

Epsom salt, $MgSO_4 \cdot 7H_2O$ is used as mild **laxative** or **purgative**. Barium sulphate is used as a white pigment. Calcium sulphate can exist as a hemihydrate $CaSO_4 \cdot \frac{1}{2} H_2O$ which is important in the building trade as **plaster of Paris**. This is made by partial dehydration of **gypsum**.

$$\underset{\text{Gypsum}}{CaSO_4 \cdot 2H_2O} \xrightarrow{150°C} \underset{\text{Plaster of Paris}}{CaSO_4 \cdot \frac{1}{2} H_2O} \xrightarrow{200°C} \underset{\text{Anhydrite}}{CaSO_4} \xrightarrow{1100°C} CaO + SO_3$$

When powdered plaster of Paris ($CaSO_4 \cdot \frac{1}{2} H_2O$) is mixed with the correct amount of water, it sets into a solid mass of $CaSO_4 \cdot 2H_2O$ (gypsum).

Alabaster is a fine grained form of $CaSO_4 \cdot 2H_2O$ which is shiny like marble, and is used to make ornaments. $CaSO_4$ is slightly soluble in water, therefore, objects made from alabaster or gypsum cannot be kept outdoors.

Plaster of Paris is used for plastering walls, and also to make plaster casts for variety of purposes, industrial, sculptural, and in hospitals to encase limbs so that broken bones are set straight.

$BaSO_4$ is both insoluble in water and opaque to X-rays, and is used as a **barium meal** to provide a shadow of the stomach or duodenum on an X-ray picture, which is useful in diagnosing stomach or duodenal ulcers. The sulphates all decompose on heating, giving the oxides.

$$MgSO_4 \xrightarrow{\Delta} MgO + SO_3$$

The order of the stability of the sulphates is as—

$BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$

Key Points

- The solubility products of hydroxides of alkaline earth elements increase on going down the group and those of sulphates of these elements follow reverse order as is evident from following data—

Hydroxides	Solubility products	Sulphates	Solubility products
$Be(OH)_2$	1.6×10^{-26}	$BeSO_4$	Very high
$Mg(OH)_2$	8.9×10^{-12}	$MgSO_4$	High
$Ca(OH)_2$	1.3×10^{-4}	$CaSO_4$	2.4×10^{-5}
$Sr(OH)_2$	3.2×10^{-4}	$SrSO_4$	7.6×10^{-7}
$Ba(OH)_2$	5.4×10^{-2}	$BaSO_4$	1.5×10^{-9}
		$RaSO_4$	4.0×10^{-11}

- The solubility of hydroxides increases and that of sulphates decreases down the group.
- When lattice energy is high, the solubility will be low. If hydration energy is high, the ions will have greater tendency to be hydrated, and, therefore, solubility will be high.
- In the case of sulphates of alkaline earth elements, the lattice energy is almost same. The sulphate ion itself is so large (radius = 3Å) that relatively small change in metallic ionic size from Be^{2+} to Ba^{2+} do not make any material difference. However, the hydration energy of metal cations, from Be^{2+} to Ba^{2+} decreases in this order. Hence, the solubility of sulphates decreases in this order. *i.e.*, the solubility decreases with increase in ionic size.
- In case of the hydroxides, the lattice energies are different because, the hydroxide ion is not large and, therefore, even small change in metallic ionic sizes do make a difference. Thus as the metallic ionic size increases on moving from Be^{2+} to Ba^{2+}, the lattice energy decreases. This tends to enhance the solubility and to overcome the counter-effect produced by the decrease in hydration energy. Hence, the solubility of hydroxides increases on moving down the group.

Halides—The metals combine directly with halogens on heating at appropriate temperature forming halides, MX_2. The halides can also be obtained by reacting metal carbonates with dilute halogen acids.

Beryllium halides (BeF_2, $BeCl_2$), on account of smaller size of Be^{2+} ion, are covalent and, therefore, do not conduct electricity in molten state. They are hygro-

scopic and fume in air due to hydrolysis. They sublime on heating. Anhydrous beryllium halides cannot be obtained from materials made in aqueous solutions because the hydrated ions like $[Be(H_2O)_4]Cl_2$ or $[Be(H_2O)_4]F_2$ are formed. Attempts to dehydrate them result in hydrolysis.

$$[Be(H_2O)_4]Cl_2 \xrightarrow{\Delta} Be(OH)_2 + 2HCl$$

However, the following reactions give anhydrous beryllium halides.

$$BeO + 2NH_3 + 4HF \longrightarrow (NH_4)_2[BeF_4]$$

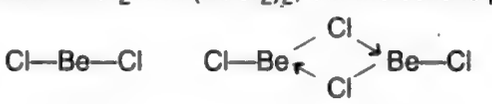
$$\downarrow \text{Heat}$$

$$BeF_2 + 2NH_4F$$

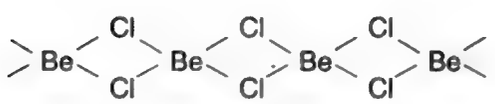
$$BeO + C + Cl_2 \underset{}{\overset{700^\circ C}{\rightleftharpoons}} BeCl_2 + CO$$

$$2BeO + CCl_4 \xrightarrow{800^\circ C} 2BeCl_2 + CO_2$$

The anhydrous halides are polymeric. $BeCl_2$ vapour contains $BeCl_2$ and $(BeCl_2)_2$, but the solid is polymerised.



(i) (ii)



(iii)

The chlorides and fluorides of other alkaline earth elements are ionic solids and good conductors of electricity in the fused as well as in the dissolved state. $CaCl_2$ has great affinity for water and is good dehydrating agent. The solubility of halides in water decreases with increasing atomic number of metal. The fluorides are almost insoluble.

Biological Role of Mg^{2+} and Ca^{2+} ions :

Mg^{2+} ions are concentrated in animal cells and Ca^{2+} ions are concentrated in the body fluids outside the cell, in much the same way that K^+ concentrates inside the cell and Na^+ outside. Mg^{2+} ions forms complex with ATP and are constituents of **phosphohydrolases** and **phosphotransferases,** which are enzymes for the reactions involving ATP and energy release. They are also essential for transmission of impulses along nerve fibres. Mg^{2+} is important in chlorophyll, in the green parts of plants. Ca^{2+} is important in bones and teeth as **apatite** $Ca_3(PO_4)_2$, and enamel on teeth as **fluorapatite** $[3(Ca_3(PO_4)_2CaF_2]\ Ca^{2+}$ ions are important in blood clotting, and are required to trigger the contraction of muscles and to maintain the regular beating of the heart.

Portland Cement :

Portland cement is one of the most important building materials. It was discovered in England. On setting it hardens to a stone-like mass, it was equalised to the famous Portland Rock of England and named as Portland cement. Cement is essentially a mixture of calcium silicates and calcium aluminates with small amounts of gypsum.

The essential raw materials used are lime-stone and clay. Lime-stone ($CaCO_3$) provides calcium oxide and clay provides silica as well as alumina and ferric oxide.

Following reactions occur during the manufacture of cement—

$$2CaO + SiO_2 \rightarrow \underset{\text{Dicalcium silicate}}{2CaO\cdot SiO_2}$$

$$3CaO + SiO_2 \rightarrow \underset{\text{Tricalcium silicate}}{3CaO\cdot SiO_2}$$

$$3CaO + Al_2O_3 \rightarrow \underset{\text{Tricalcium aluminate}}{3CaO\cdot Al_2O_3}$$

$$4CaO + Al_2O_3 + Fe_2O_3 \rightarrow \underset{\text{Tetracalcium alumino ferrite}}{4CaO\cdot Al_2O_3\cdot Fe_2O_3}$$

Out of the above compounds, the tricalcium silicate is the most important. This substance has the property of setting quickly and developing considerable strength within a few days. It generally constitute about 50 percent of cement. Tricalcium aluminate sets instantaneously in the presence of water. The internal strength acquired by cement is primarily due to setting of tricalcium aluminate.

The mixture of products of above reactions is known as **cement clinker**. After cooling, it is mixed with 2 or 3 percent gypsum and ground to fine powder. The function of gypsum is to slow down the setting process so that it gets sufficiently hardened.

Setting of cement—This involves many complicated reactions. This is a known fact that while first setting takes place within 24 hours , the subsequent hardening requires about a fortnight. This is supported by the fact that subsequent hardening of the cement takes place when it is covered by a layer of water.

Primarily, the reactions involved are the hydration of calcium aluminate and calcium silicate which change into their colloidal gels. At the same time some calcium hydroxide and aluminium hydroxide are formed as the precipitates due to hydrolysis. Calcium hydroxide binds the particles of calcium silicate together while aluminium hydroxide fills the interstices rendering the mass impervious. Various reactions involved during the process of setting are as—

(a) $\underset{\text{Tricalcium aluminate}}{3CaO\cdot Al_2O_3} + 6H_2O \rightarrow \underset{\text{Hydrated colloidal gel of tricalcium aluminate}}{3CaO\cdot Al_2O_3\cdot 6H_2O}$

(b) $\underset{\text{Tricalcium silicate}}{3CaO\cdot SiO_2} + H_2O \rightarrow Ca(OH)_2 + \underset{\text{Dicalcium silicate}}{2CaO\cdot SiO_2}$

(c) $\underset{\text{Dicalcium silicate}}{2CaO\cdot SiO_2} + xH_2O \xrightarrow{\text{Slow process}} \underset{\text{Hydrated colloidal gel of dicalcium silicate}}{2CaO\cdot SiO_2\cdot xH_2O}$

(d) $\underset{\text{Tricalcium aluminate}}{3CaO\cdot Al_2O_3} + 6H_2O \longrightarrow 3Ca(OH)_2 + 2Al(OH)_3$

(e) $\underset{\text{Tetracalcium alumino ferrite}}{4CaO\cdot Al_2O_3\cdot Fe_2O_3} + 6H_2O \rightarrow \underset{\text{Hydrated colloidal gel of tricalcium aluminate}}{3CaO\cdot Al_2O_3\cdot 6H_2O} + CaO\cdot Fe_2O_3$

(f) **Role of gypsum**—

$$3CaO\cdot Al_2O_3 + 3CaSO_4 + 2H_2O \rightarrow \underset{\text{Calcium sulpho aluminate}}{3CaO\cdot Al_2O_3\cdot 3CaSO_4\cdot 2H_2O}$$

Thus the quick setting results in the formation of crystalline hydrated calcium aluminate whereas a slow setting yields the colloidal gel which imparts much greater strength to the set mass.

Heat of hydration—The hydration of calcium aluminate and calcium silicate involved in the setting process is an exothermic change. Hence, cement structures have to be cooled during the setting. At big structures like dams, the cement concrete mixture is pre-chilled to avoid uneven expansion of the mass, failing which the cracks are produced in the structure. In case of small structures, the heat of hydration is removed by sprinkling water.

Points to Remember

- Calcium carbide, CaC_2 on heating with nitrogen at 1100°C gives calcium cyanamide, $CaCN_2$. Calcium cyanamide mixed with carbon as obtained in the reaction itself, is used as a nitrogenous fertilizer.

$$CaC_2 + N_2 \xrightarrow{1100^\circ C} CaCN_2 + C;\ \Delta H = -304{\cdot}2\ kJ$$

- In the soil calcium cyanamide first changes into calcium carbonate and cyanamide

$$CaCN_2 + H_2O + CO_2 \rightarrow CaCO_3 + \underset{\text{Cyanamide}}{H_2NCN}$$

The cyanamide then hydrolysis in two steps forming ammonia.

$$H_2N{\cdot}CN + H_2O \rightarrow \underset{\text{Urea}}{CO(NH_2)_2}$$

$$CO(NH_2)_2 + H_2O \rightarrow CO_2 + 2NH_3$$

Ammonia is finally converted to nitrates through the action of nitrifying bacteria.

- In nuclear reactors, the beryllium salts are used as the source of neutrons.

$${}_4Be^9 + {}_2He^4 \rightarrow {}_6C^{12} + {}_0n^1$$

- Magnesium powder mixed with potassium chlorate ($KClO_3$) is used in **flash-bulbs** for photography. The flash powder burns quickly producing intense ultraviolet light.
- Magnesium ribbon is used for igniting the thermite in alumino-thermic process.
- Magnesium in the form of Grignard reagents is largely used for synthesis of many organic compounds.
- Calcium metal is used in removing traces of water from alcohol because unlike sodium, it does not react with alcohol.
- Calcium is used as a **deoxidiser** for copper, cast iron and steel, and as a **desulphuriser** in oil refining.
- Ca, Sr, Ba and Ra give characteristic colour to the flame.

  Ca : **brick red**; Sr : **crimson**, Ba : **apple green**, Ra : **crimson**

  Be and Mg on account of the smaller atomic sizes do not impart any colour to the flame. The electrons in these atoms are not excited by the energy of the flame.
- The sulphates of Ca, Sr and Ba are insoluble, and the carbonates, oxalates, chromates and fluorides of the whole group are insoluble.
- Hard water contains dissolved salts such as magnesium and calcium carbonates, bicarbonates or sulphates. The metal ions (Ca^{2+}, Mg^{2+}) react with stearate ions of the soap forming an insoluble scum of calcium or magnesium stearates before any lather is produced. Hard water also produces scale (insoluble deposits) in water pipes, boilers and kettles.
- The **temporary hardness** of water is due to the presence of $Mg(HCO_3)_2$ and $Ca(HCO_3)_2$. It is called temporary because it can be removed by boiling, which drives off CO_2 and upsets the equilibrium.

$$2HCO_3^- \rightleftharpoons CO_3^{2-} + CO_2 + H_2O$$

The temporary hardness can also be removed by adding slaked lime to precipitate calcium carbonate. This is called **'lime softening'**.

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightleftharpoons CaCO_3 + 2H_2O$$

- The **permanent hardness** of water is mainly due to dissolved $MgSO_4$ and $CaSO_4$. This hardness cannot be removed by boiling. Small quantities of pure water are prepared in the laboratory either by distillation or by passing it through an ion-exchanger, where Ca^{2+} and Mg^{2+} ions are replaced by Na^+ ions.
- Water may be softened by adding various phosphates, such as—

  Na_3PO_4 (Trisodium phosphate)

  $Na_4P_2O_7$ (Sodium pyrophosphate)

  $Na_5P_3O_{10}$ (Sodium tripolyphosphate)

  $(NaPO_3)_n$ (Grahams salt), also known as **calgon**.

  These phosphates form complexes with Ca^{2+} and Mg^{2+} ions and **sequester** them, *i.e.*, keep them in solution.
- At one time large quantities of Na_2CO_3 were used in the lime-soda process to soften water.

$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$$

- The hydrated magnesium chloride, $MgCl_2{\cdot}6H_2O$, on ignition produces a residue of MgO.

$$2(MgCl_2{\cdot}6H_2O) \xrightarrow{200^\circ C} \underset{\text{or } Mg_2OCl_2}{MgO{\cdot}MgCl_2} + 2HCl + 11H_2O$$

$$2Mg_2OCl_2 + O_2 \xrightarrow{600^\circ C} 4MgO + 2Cl_2$$

No such reaction is given by the hydrated chlorides of other alkaline earth elements.

- $MgCO_3$ is not precipitated by $(NH_4)_2CO_3$ in presence of NH_4Cl. Carbonates of Ca, Sr and Ba get precipitated under these conditions.
- Magnesium sulphate (Epsom salt) is **isomorphic** with zinc sulphate as they have similar composition and crystalline structure.

$$MgSO_4{\cdot}7H_2O$$
$$ZnSO_4{\cdot}7H_2O$$

- All elements of Group-II burn in nitrogen to give nitrides (M_3N_2). Beryllium nitride is volatile while other are not.
- In nature barium occurs as **Barytes** or **Heavy spar** ($BaSO_4$) and as **Witherite** ($BaCO_3$).
- $MgCl_2{\cdot}5MgO{\cdot}xH_2O$ is called **sorel cement** or **magnesia cement**.
- $Mg(OH)_2$ in an aqueous suspension is used in medicine as **antacid** under the name of **milk of magnesia**.
- Magnesium perchlorate [$Mg(ClO_4)_2$] is commercially used as very effective drying agent under the name of **anhydrone**.
- **Asbestos** is calcium-magnesium silicate having composition $CaMg_3(SiO_3)_4$.
- **Lithopone** is a mixture of $BaSO_4$ and ZnS. It is a white pigment.
- **Magnalium** is an alloy of Mg and Al and **Elecktron** is an alloy of Mg and Zn.
- The **Epsom salt**, $MgSO_4{\cdot}7H_2O$ is used as purgative in veterinary medicines.
- Crystalline magnesia, MgO is a useful material, because it is stable at high temperature and is a good conductor of heat. However, it is a poor conductor of electricity. These properties make it useful as an insulator for the wires within electrical heating units, such as the ones in a home cooking range or space heater.

OBJECTIVE QUESTIONS

1. Which of the following compounds absorbs CO_2 and reacts with water violently ?
   (A) ZnO (B) H_2SO_4
   (C) CaO (D) $CaCO_3$

2. The correct order of thermal stability of the following carbonates
   $BaCO_3$, $CaCO_3$, $MgCO_3$
   is—
   (A) $BaCO_3 > CaCO_3 > MgCO_3$
   (B) $CaCO_3 > MgCO_3 > BaCO_3$
   (C) $MgCO_3 > CaCO_3 > BaCO_3$
   (D) $BaCO_3 > MgCO_3 > CaCO_3$

3. The element found in plant system which makes an important part of photosynthesis is—
   (A) Iron (B) Copper
   (C) Sodium (D) Magnesium

4. Portland cement is prepared by using—
   (A) Limestone, clay and gypsum
   (B) Limestone, gypsum, alumina
   (C) Limestone, clay and sand
   (D) Limestone, gypsum and sand

5. A fire works gives out crimson coloured light, it contains a salt of—
   (A) Sodium (B) Calcium
   (C) Barium (D) Strontium

6. The substance which is commonly used in laboratory dessicator, is—
   (A) NaCl (B) Na_2CO_3
   (C) Na_2SO_4 (D) $CaCl_2$

7. The setting of the plaster of Paris is—
   (A) Carbonation
   (B) Dehydration
   (C) Oxidation
   (D) Hydration to give another hydrate

8. The wires of flash bulbs are made of—
   (A) Tungsten (B) Magnesium
   (C) Sodium (D) Mercury

9. Magnesium burns in the atmosphere of—
   (A) Nitrogen dioxide
   (B) Carbon monoxide
   (C) Nitrogen
   (D) None of these

10. The mixture of $MgCl_2$ and MgO is known as—
    (A) Double salt
    (B) Portland cement
    (C) Sorel cement
    (D) None of these

11. Which of the following salts has highest solubility in water ?
    (A) Barium sulphate
    (B) Calcium sulphate
    (C) Magnesium sulphate
    (D) Beryllium sulphate

12. A piece of magnesium ribbon was heated to redness in the atmosphere of nitrogen and then cooled with water. The gas evolved is—
    (A) Hydrogen (B) Nitrogen
    (C) Ammonia (D) Oxygen

13. Calcium chloride and potassium chloride solution can be distinguished from one another by—
    (A) Adding NH_4OH to each solution
    (B) Performing the flame test
    (C) Adding $AgNO_3$ to each solution
    (D) Comparing the colours of the solution

14. In which of the following pairs of substances, both give same gaseous products on reacting with water ?
    (A) Ba and BaO_2
    (B) Na and Na_2O_2
    (C) Ca and CaH_2
    (D) K and KO_2

15. Which of the following metal ions plays an important role in muscle contraction ?
    (A) Na^+ (B) K^+
    (C) Mg^{+2} (D) Ca^{2+}

16. Soda lime is—
    (A) NaOH and $Ca(OH)_2$
    (B) NaOH and Na_2O
    (C) NaOH and CaO
    (D) NaOH and Na_2CO_3

17. The electronic configuration of alkaline earth elements is represented by—
    (A) np^2 (B) ns^1
    (C) ns^2 (D) ns^1nd^{n-1}

18. Which one of the following is not the electronic configuration of alkaline earth elements ?
    (A) [Kr] $5s^2$
    (B) [Xe] $6s^2$
    (C) [Rn] $7s^2$
    (D) [Ar] $3d^{10}4s^2$

19. Which of the following elements forms the least ionic chloride ?
    (A) Beryllium (B) Magnesium
    (C) Barium (D) Radium

20. The hydration energy of Mg^{2+} is higher than that of—
    (A) Mg^{3+} (B) Al^{3+}
    (C) Be^{2+} (D) Na^+

21. The chemical composition of carnallite is—
    (A) $CaCl_2 \cdot MgCl_2 \cdot 6H_2O$
    (B) $MgCl_2 \cdot MgO \cdot 6H_2O$
    (C) $KCl \cdot MgCl_2 \cdot 6H_2O$
    (D) $K_2CO_3 \cdot MgSO_4$

22. Which of the following oxides is the most basic ?
    (A) Al_2O_3 (B) SiO_2
    (C) P_2O_5 (D) MgO

23. Amongst LiCl, $BeCl_2$, RbCl and $MgCl_2$, the chlorides with the greatest and least ionic character respectively are—
    (A) LiCl, RbCl
    (B) RbCl, $MgCl_2$
    (C) $BeCl_2$, RbCl
    (D) RbCl, $BeCl_2$

24. Anhydrous $MgCl_2$ can be prepared by heating $MgCl_2 \cdot 2H_2O$—
    (A) With charcoal
    (B) Until it becomes red hot
    (C) In a current of HCl gas
    (D) With slaked lime

25. Which is known as lithopone ?
    (A) $MgSO_4 \cdot 7H_2O$
    (B) $CaH_2 + ZnO$
    (C) $BaSO_4 + ZnS$
    (D) $ZnSO_4 + BaS$

26. Magnesium burns in air to produce ?
    (A) MgO
    (B) Mg_3N_2

(Continued on Page 104)

ALCOHOLS

Introduction :

The word alcohol is derived from the Arabic Kuhl (also Kohl or Kohol). It originally was used to mean a 'very fine powder' but gradually came to cannote 'essence'. Later the term was applied to wine spirits, which were referred to as alcool vini, and eventually simply alcohol. The compounds derived from hydrocarbons by replacement of one or more hydrogens by hydroxyl groups are known as organic hydroxy compounds. The parent hydrocarbons may be acyclic aliphatic saturated or unsaturated. The hydroxyl compounds which are derived from acyclic and alicyclic hydrocarbons are called **alcohols**. Those obtained by replacement of nuclear aromatic hydrogens are called **Phenols**. Since phenols differ from alcohols in many respects, they are treated separately from alcohols. Aryl substituted alcohols ($C_6H_5CH_2OH$) are also known as **aromatic alcohols**.

Alcohols are classified as mono, di, tri and poly hydric alcohols according to the number of hydroxyl groups present in their molecules. For example :

CH_3CH_2OH	CH_2OH | CH_2OH	CH_2OH | $CHOH$ | CH_2OH	CH_2OH | $(CHOH)_4$ | CH_2OH
Ethyl alcohol (Monohydric)	Ethylene glycol (Dihydric)	Glycerol (Trihydric)	Sorbitol (Polyhydric)

Alcohols may be primary, secondary or tertiary according as the hydroxyl group is attached to primary, secondary or tertiary carbon atom. For example :

Primary ($-CH_2-OH$)

Methyl alcohol	CH_3OH
Ethyl alcohol	CH_3CH_2OH
Propyl alcohol	$CH_3CH_2CH_2OH$

Secondary ($>CHOH$)

Isopropyl alcohol	$(CH_3)_2CHOH$

Tertiary ($\geqslant C-OH$)

Trimethyl carbinol	$(CH_3)_3COH$

Nomenclature :

There are three systems of naming alcohols :

(i) Common or trivial system

(ii) Carbinol system and

(iii) IUPAC system.

Formula	Parent hydro-carbon	Common name	Carbinol name	IUPAC name
CH_3OH	Methane	Methyl alcohol	Carbinol	Methanol
CH_3CH_2OH	Ethane	Ethyl alcohol	Methyl carbinol	Ethanol
$CH_3\underset{\displaystyle OH}{\underset{\vert}{C}}HCH_3$	Propane	Isopropyl alcohol	Dimethyl carbinol	2-Propanol
$(CH_3)_3COH$	2-Methyl propane	Tert-butyl alcohol	Trimethyl carbinol	2-Methyl-2-propanol

Ethanol is known as ethyl alcohol, grain alcohol and the spirit of wine. The first system of nomenclature for alcohols, which was based on the use of the term 'carbinol' for methanol, was originated by a 19th century German chemist **Hermann Kolbe**. The carbinol nomenclature is gradually fading out of usage. The presently accepted systematic nomenclature for alcohols was adopted at a meeting of the **International Union** of **Pure and Applied Chemistry** (IUPAC), in **Paris** in 1957.

Occurrence in Nature :

Alcohols in free form are not a common occurrence in the nature; they are found mainly in the essential or volatile oils obtained from the flowers, leaves, and stems of the plants. Chiefly, these are a group of monohydric primary alcohols with carbon chains of 7 to 12 atoms. Their characteristic odours make them valuable ingredient of perfumes. More complex alcohols with branched structures and unsaturated linkages, such as citronellol and geraniol, both 10-carbon alcohols, are found in rose and geranium oils and are isolated from citronella oil. The fatty alcohols (primary alcohols with long, straight carbon chains), cinnamyl alcohol ($C_6H_5CH=CHCH_2OH$), phenylpropyl alcohol ($C_6H_5CHOHC_2H_5$), and menthol and terpineol (cyclic 10-carbon alcohols) are other alcohols that occur naturally. Several sugar alcohols, containing respectively, four and five hydroxyl groups on as many carbon atoms, are found in mosses, lichens, and yeasts. **Sorbitol**, a six carbon, six hydroxyl alcohol occurs widely in fruits, berries, algae, and red sea-weeds. **Mannitol**, an isomer of sorbitol, is a major component of the exudate of olive and manna ash trees, and is found in pumpkin, grasses, mushrooms, marine algae and brown seaweeds. **Sterols**, such as **Cholesterol**, are present in both animal and vegetable kingdoms.

Specific alcohols, such as ethanol, methanol, and glycerol, are consumed in enormous amounts for thousands of applications. Generally the alcohols produced from natural sources are expensive, difficult to purify, and somewhat unpredictable in their availability. Therefore, in

order to meet the demands of industry for alcohols of many descriptions in pure forms and at low cost, producers have developed special processes that form alcohols from readily available raw materials under carefully controlled conditions.

General Methods of Preparation :

1. **Hydrolysis of halides**—Alkyl halides, when boiled with aqueous solution of an alkali hydroxide, give alcohols through nucleophilic substitution mechanism.

$$R{-}X + KOH \longrightarrow R{-}OH + KX$$

This general procedure produces primary and secondary alcohols. Glycerol can be synthesized from propylene by a series of reactions including the hydrolysis of a halide as one step in the process.

Unsaturated alcohols can be prepared by high temperature chlorination followed by hydrolysis of intermediate halide of an alkene. An example is the production of alkyl alcohol from propylene.

$$\underset{\text{Propylene}}{CH_2{=}CHCH_3} + Cl_2 \longrightarrow \underset{\text{Allyl chloride}}{CH_2{=}CHCH_2Cl} + HCl$$

$$CH_2{=}CHCH_2Cl + NaOH \longrightarrow CH_2{=}CHCH_2OH + NaCl$$

Allyl alcohol

Note—There is a serious limitation of this method. Elimination is a serious competing reaction specially with sec. and tert-halides. However, if a weaker nucleophile like silver acetate (AgOAc) replaces alkali hydroxide, better results are obtained even with tert. halides. For example :

$$\underset{\text{tert-Butyl chloride}}{(CH_3)_3CCl} + AgO\overset{\displaystyle O}{\overset{\|}{C}}CH_3 \longrightarrow (CH_3)_3C{-}O{-}\overset{\displaystyle O}{\overset{\|}{C}}CH_3 + AgCl$$

tert-Butyl acetate

$$(CH_3)_3{-}C{-}O{-}\overset{\displaystyle O}{\overset{\|}{C}}CH_3 \xrightarrow{H_2O} (CH_3)_3C{-}OH + CH_3COOH$$

tert-Butyl alcohol

As alkyl halides themselves are prepared from alcohols, this method will be of interest only when alkyl halides are readily available and are very cheap.

2. **Hydration of Alkenes**—(a) Direct hydration takes place by adding water in presence of catalyst.

$$\underset{\text{2-Methylpropene}}{CH_3{-}\overset{\displaystyle CH_3}{\overset{|}{C}}{=}CH_2} + H_2O \xrightarrow{H^{\oplus}} (CH_3)_3C{-}\overset{\oplus}{O}H_2 \xrightarrow{-H^{\oplus}} \underset{\text{2-Methylpropane-2-ol}}{(CH_3)_3{-}C{-}OH}$$

(b) Indirect hydration is achieved by addition of sulphuric acid to alkene followed by hydrolysis of the alkyl hydrogen sulphate.

$$\underset{\text{Ethene}}{CH_2{=}CH_2} + H_2SO_4 \longrightarrow CH_3CH_2OSO_2OH \xrightarrow[\Delta]{H_2O} \underset{\text{Ethanol}}{CH_3CH_2OH}$$

$$\underset{\text{Propene}}{CH_3CH{=}CH_2} + H_2SO_4 \longrightarrow CH_3CH(OSO_2OH)CH_3 \xrightarrow[\Delta]{H_2O} \underset{\text{2-Propanol}}{CH_3CH(OH)CH_3}$$

3. **Hydroformylation of Alkenes**—Lower molecular weight olefins react with carbon monoxide and hydrogen in the presence of a catalyst in a reaction called hydroformylation or the **oxo reaction.**

$$\underset{\text{Alkene}}{>C{=}C<} + CO + H_2 \xrightarrow{\text{Cobalt}} \underset{\text{Aldehyde}}{>CH{-}\overset{|}{\underset{|}{C}}{-}\overset{|}{\underset{|}{C}}{=}\overset{O}{\underset{H}{<}}}$$

The resulting aldehyde is subsequently hydrogenated to form an alcohol.

$$>CH{-}\overset{|}{\underset{|}{C}}{-}\overset{|}{\underset{|}{C}}{=}\overset{O}{\underset{H}{<}} + H_2 \longrightarrow \underset{\text{Alcohol}}{>CH{-}\overset{|}{\underset{|}{C}}{-}CH_2OH}$$

4. **Hydroboration-oxidation of alkenes**—Alkenes when treated with diborane $(BH_3)_2$, give alkylboranes, R_3B. Alkylboranes on oxidation with alkaline hydrogen peroxide give alcohols.

$$\underset{\text{Ethene}}{6CH_2{=}CH_2} \xrightarrow{(BH_3)_2} \underset{\text{Triethyl borane}}{2(CH_3CH_2)_3B} \xrightarrow{H_2O_2/OH^-} \underset{\text{Ethanol}}{6\,CH_3CH_2OH}$$

$$\underset{\text{Propene}}{6CH_3CH{=}CH_2} \xrightarrow{(BH_3)_2} \underset{\text{Tri-}n\text{-propylborane}}{2(CH_3CH_2CH_2)_3B} \xrightarrow{H_2O_2/OH^-} \underset{\text{1-Propanol}}{6CH_3CH_2CH_2OH}$$

Note—It is significant to note that this method always leads to the **anti-Markovnikov's addition** of water to alkenes.

5. **Grignard Synthesis**—All the three types of alcohols (primary, secondary, tertiary) can be prepared from the Grignard reagents by interaction with suitable carbonyl compounds.

$$\underset{\text{Grignard reagent}}{R{-}MgX} + \underset{\text{Ketone}}{\overset{R'}{\underset{R''}{>}}C{=}O} \rightarrow$$

$$\overset{R'}{\underset{R''}{>}}C{-}OMgX \xrightarrow[H^+]{H_2O} \underset{\text{Alcohol}}{\overset{R'}{\underset{R''}{>}}C{-}OH} + Mg(OH)X$$

The reaction of Grignard reagent with formaldehyde leads to primary alcohols, that with aldehydes other than formaldehyde yield secondary alcohols and that with ketones give tertiary alcohols.

Mechanism of above reaction is illustrated as :

(i) $R{-}\overset{\cdot\cdot}{\underset{\cdot\cdot}{}}MgX \rightarrow \bar{R} : + \overset{+}{M}gX$

(ii) $\overset{\ominus}{R} : + \underset{|}{\overset{|}{C}}{=}O \rightarrow R{-}\overset{|}{\underset{|}{C}}{-}\overset{-}{O}\,\overset{+}{M}gX$

$+ \overset{+}{M}gX$

(iii) $R-\underset{|}{\overset{|}{C}}-O-MgX + HOH \rightarrow R-\underset{|}{\overset{|}{C}}-OH + Mg(OH)X$

(iv) $Mg(OH)X + H^+ \rightarrow Mg^{2+} + X^- + H_2O$

6. **Reduction of Carbonyl Compounds**—Carbonyl compounds *i.e.*, aldehydes and ketones etc. give alcohols on reduction. This reaction can be effected by :

(i) Catalytic hydrogenation

(ii) The use of metal-solvent combination such as sodium or potassium in alcohol.

(iii) The use of complex metal hydrides.

For example :

(i) $CH_3-\overset{O}{\overset{\|}{C}}-CH_3 + H_2 \xrightarrow{PtO_2} CH_3\overset{OH}{\overset{|}{C}}H-CH_3$
2-Propanone → 2-Propanol

(ii) $CH_3CHO + H_2 \xrightarrow[\text{or } LiAlH_4]{Ni} CH_3CH_2OH$
Ethanal → Ethanol

(iii) $\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!C=O + H_2 \xrightarrow[\text{or } LiAlH_4]{Ni} CH_3CH(OH)-CH_3$
Propanone → 2-Propanol

(iv) $CH_3-\overset{O}{\overset{\|}{C}}-CH_2CH_2CH_3 + H_2 \xrightarrow[EtOH]{Na} CH_3CHOHCH_2CH_2CH_3$
Pentanone-2 → 2-Pentanol

(v) $C_2H_5COOC_2H_5 + 2H_2 \xrightarrow[EtOH]{Na} C_2H_5CH_2OH + C_2H_5OH$
Ethyl propanoate → 1-Propanol + Ethanol

Note—Aldehydes and ketones, in presence of metals like magnesium undergo **bimolecular reduction** to form symmetrical glycols **(Pinacols)**. For example :

$CH_3-\overset{CH_3}{\overset{|}{C}}(=O) + \overset{CH_3}{\overset{|}{C}}(=O)-CH_3 \xrightarrow{Mg} CH_3-\underset{O}{\overset{CH_3}{\overset{|}{C}}}-\underset{O}{\overset{CH_3}{\overset{|}{C}}}-CH_3$
Propanone → Mg complex

$\xrightarrow{H_2O} CH_3-\overset{CH_3}{\overset{|}{C}}(OH)-\overset{CH_3}{\overset{|}{C}}(OH)-CH_3$
2, 3-Dimethyl butane 2, 3-diol (Pinacol)

More about the Preparation of Alcohols :

- **Oxymercuration—Demercuration** of alkenes leads to the formation of alcohols. It involves the reaction of alkene with mercuric acetate in presence of tetrahydrofuran (THF). This step is known as **Oxymercuration** as :

$R_2-\overset{R}{\overset{|}{C}}=\overset{R_3}{\overset{|}{C}}-R_4 \xrightarrow[THF-H_2O]{Hg(OCOCH_3)_2} R^2-\overset{R^1}{\overset{|}{C}}(OH)-\overset{R^3}{\overset{|}{C}}(HgOCOCH_3)-R^4$

This is followed by the reduction of intermediate hydroxy mercuryl compounds known as **demercuration**.

$R^2-\overset{R^1}{\overset{|}{C}}(OH)-\overset{R^3}{\overset{|}{C}}(HgOCOCH_3)-R^4 \xrightarrow{NaBH_4} R^2-\overset{R^1}{\overset{|}{C}}(OH)-\overset{R^3}{\overset{|}{C}}(H)-R^4$
Hydroxy mercuryl compound → Alcohol

Alcohols obtained are those which will be formed by the Markovnikov's addition of H_2O to carbon-carbon double bond.

- **Grignard reagents** also react with ethylene oxide to form primary alcohols containing two carbon atoms more than the Grignard reagent.

$CH_3MgBr + \underset{O}{CH_2-CH_2} \xrightarrow{H_2O/H^+} CH_3CH_2CH_2OH$
Grignard reagent; Ethylene oxide → Propanol-1

Mechanism of this reaction can be illustrated as below :

$CH_3-MgX \longrightarrow \overset{\ominus}{\ddot{C}}H_3 + \overset{\oplus}{M}gX$

$:CH_3 + \underset{O}{CH_2-CH_2} \rightarrow CH_3CH_2CH_2\overset{\ominus}{O}$

$CH_3CH_2CH_2\overset{\ominus}{O} \xrightarrow{H^+} CH_3CH_2CH_2OH$
Propanol-1

This reaction sequence is useful in ascending the series of organic compounds.

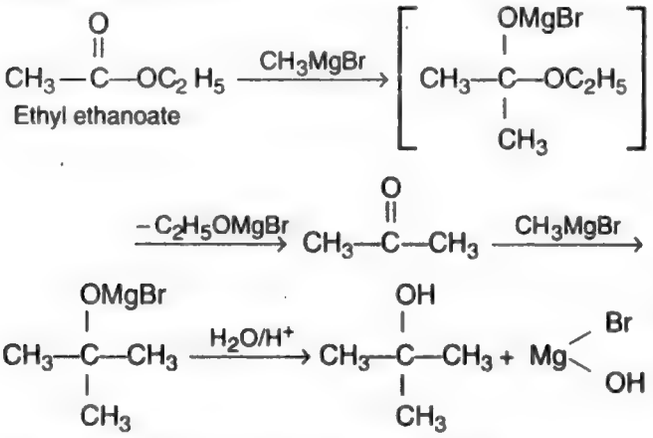
- **Hydroxylation of alkenes** leads to the formation of 1, 2-glycols. For example :

$CH_2=CH_2 \xrightarrow{KMnO_4} \underset{\text{Ethane-1, 2-diol}}{CH_2(OH)-CH_2(OH)}$
Ethene

$CH_2=CH_2 \xrightarrow[H_2O/H^+]{C_6H_5CO_2OH} CH_2(OH)-CH_2(OH)$
Ethane-1, 2-diol

$KMnO_4$ leads to syn-hydroxylation or cis-hydroxylation and per acids to anti-hydroxylation or trans-hydroxylation of alkenes, where structure permits.

- All esters, except that of formic acid yield tertiary alcohols on reaction with Grignard reagent followed by acidic hydrolysis. The esters of formic acid give secondary alcohols.

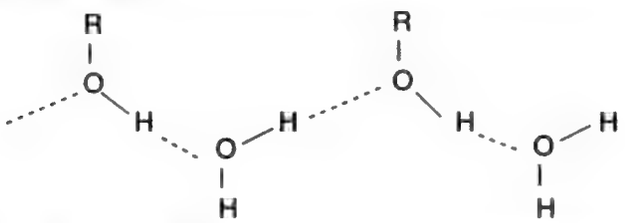


General Physical Properties of Alcohols :

The lower members of alcohols are colourless, volatile liquids with a characteristic alcoholic smell and burning taste, whereas higher alcohols are odourless and tasteless. Alcohols having 12 or more than 12 carbon atoms are solids. Branched chain alcohols with much fewer carbon atoms are, however, solids.

Solubility in Water—The first three members are completely miscible with water. The higher members are practically insoluble in water, but soluble in organic liquids due to the dominance of the non-polar hydrocarbon character in comparison with polar hydroxyl group.

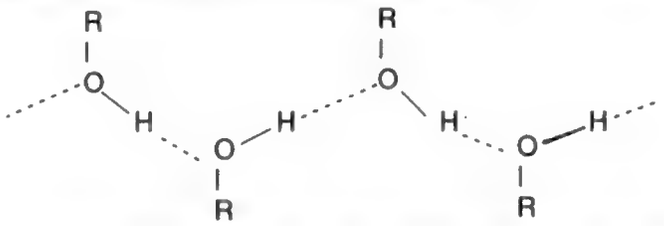
The solubility of lower alcohol is due to the existence of hydrogen bonds between water and polar-OH group of alcohol molecule.



The solubility in water decreases with increase in molecular weight because with increase in molecular mass, the non-polar alkyl group becomes predominant and masks the effect of polar —OH group. In addition, among the isomeric alcohols the solubility increases with branching of the chain. It is because the surface area of non-polar part in the molecule decreases, enhancing the solubility. For example

Alcohol	Structure	Solubility gm/100 g H_2O
n-Butyl alcohol	$CH_3CH_2—CH_2—CH_2OH$	7·9
Sec. Butyl alcohol	$CH_3—CH(OH)—CH_2—CH_3$	12·5
Isobutyl alcohol	$(CH_3)_2CH—CH_2OH$	10·00
tert-Butyl alcohol	$(CH_3)_3C—OH$	∞

Boiling points—Boiling points of alcohols are much higher than those of alkanes, haloalkanes or ethers of comparable molecular mass. This is due to the **intermolecular** hydrogen bonding in alcohols as :



For isomeric alcohols, the boiling points follow the order as : primary alcohol > secondary alcohol > tertiary alcohol.

- Lower alcohols are found to form solid derivatives with $CaCl_2$ and $MgCl_2$.

$$CaCl_2 + 4CH_3OH \longrightarrow CaCl_2 \cdot 4CH_3OH$$

$$MgCl_2 + 6C_2H_5OH \longrightarrow MgCl_2 \cdot 6C_2H_5OH$$

It is because of this reason that alcohols cannot be dried with anhydrous $CaCl_2$ and $MgCl_2$.

- Alcohols are known to have intoxicating effects. Methanol is poisonous and is not good for drinking purposes. It causes blindness. Ethanol on the other hand is used for drinking purposes.

Additional hydroxyl groups in an alcohol enhances its sweetness. For example ethanol is not sweet; propylene glycol, $C_3H_6(OH)_2$ is slightly sweet; glycerol, $C_3H_5(OH)_3$ is quite sweet; and **mannitol** $C_6H_8(OH)_6$ is so sweet that it is known as sweet alcohol.

Chemical Properties of Alcohols :

In alcohols –OH group is functional group, therefore, the chemical properties of alcohols generally involve the reactions of –OH group. These undergo **substitution** and **elimination** reactions. The chemical reactivity of alcohols also depends upon the carbon chain attached to –OH group. The reactions of alcohols can be classified into three types :

(i) Reactions involving cleavage of O—H bond
(ii) Reactions involving cleavage of C—OH bond
(iii) Reactions involving both the alkyl and hydroxyl groups.

Reactions Involving Cleavage of O—H Bond :

(a) Acidic Nature of alcohols—Since the oxygen attached to hydrogen in alcohols is highly electronegative, it facilitates the separation of the relatively positive hydrogen as H^+. In other words alcohols behave as acids as is evident from the following reactions :

Reactions with metals—When treated with metals like Na and K these liberate hydrogen with the formation of alkoxides.

$$2CH_3CH_2O—H + 2Na \longrightarrow 2CH_3CH_2\bar{O}\,Na^+ + H_2\uparrow$$

Ethanol — Sod. ethoxide

$$2\,(CH_3)_3CO—H + 2K \longrightarrow 2\,[(CH_3)_3C\bar{O}]\,K^+ + H_2\uparrow$$

tert-Butyl alcohol — Pot-tert-butoxide

$$6\,(CH_3)_2CHO\ddot{-}H + 2Al \longrightarrow \underset{\text{Isopropyl alcohol}}{}$$

$$2[(CH_3)_2CH\bar{O}]_3\,Al^{3+} + 3H_2\uparrow$$
Aluminium isopropoxide

Reactions with metal hydrides—Formation of alkoxide with evolution of hydrogen takes place.

$$R{-}O\ddot{-}H + MH \longrightarrow R{-}\bar{O}\overset{+}{M} + H_2\uparrow$$

Alcohols are very weak acids ($K_a = 10^{-16} - 10^{-18}$) even feeble than water ($K_a = 1{\cdot}78 \times 10^{-16}$). They do not turn blue litmus red. Thus alcohols are weaker acids than water but stronger than acetylene as is evident from the following reactions :

$$\underset{\text{Stronger base}}{R\bar{O}\overset{+}{Na}} + \underset{\text{Stronger acid}}{H{-}OH} \longrightarrow \underset{\text{Weaker base}}{\overset{+}{Na}\bar{O}H} + \underset{\text{Weaker acid}}{RO{-}H}$$

$$\underset{\text{Stronger base}}{HC\equiv\bar{C}\,Na^+} + \underset{\text{Stronger acid}}{ROH} \longrightarrow \underset{\text{Weaker base}}{RO^-\,Na^+} + \underset{\text{Weaker acid}}{HC\equiv CH}$$

- Thus the decreasing order of acid strength is—

  $H_2O > ROH > HC\equiv CH$

- The decreasing order of basic strength of the corresponding anions is as :

  $HC\equiv\bar{C}: > R\bar{O}: > H\bar{O}:$

Relative acid strength—Acid strength of substance depends on how well the resulting anion can accommodate the negative charge. An alkyl group being electron releasing, intensifies the negative charge on alkoxide ion and consequently the anion is rendered less stable. Thus electron releasing **inductive effect** of alkyl groups makes alcohols weaker acid than water.

$$R\rightarrow\overset{|}{\underset{|}{C}}{-}OH \rightleftharpoons R\rightarrow\overset{|}{\underset{|}{C}}{-}\bar{O} + H^+$$

This inductive effect will be greatest for tertiary alcohols, less for secondary, still less for primary and least for methanol. The decreasing order of acid strength of alcohols is as :

$CH_3OH >$ Primary > Secondary > Tertiary alcohols.

$$\underset{\text{Primary alcohol}}{R\rightarrow\overset{H}{\overset{|}{\underset{|}{C}}}\rightarrow OH} > \underset{\text{Secondary alcohol}}{R\rightarrow\overset{R}{\overset{|}{\underset{H}{C}}}\rightarrow OH} > \underset{\text{Tertiary alcohol}}{R\rightarrow\overset{R}{\overset{|}{\underset{R}{C}}}\rightarrow OH}$$

(b) Reaction with Grignard Reagent—Alcohols react with Grignard reagents to form alkanes. In these reactions the alkane is obtained from alkyl part of Grignard reagent.

$$\underset{\text{Stronger acid}}{RO\ddot{-}H} + CH_3\ddot{-}MgX \longrightarrow \underset{\text{Weaker acid}}{CH_4\uparrow} + Mg\begin{matrix}X\\OR\end{matrix}$$

This reaction can be considered as displacement of weaker acid (R – H) from its salt (Grignard reagent) by stronger acid alcohol (R – OH).

This reaction makes basis of the **Zerevitinov method** for the estimation of the number of –OH groups in an unknown compound. The volume of evolved methane is measured.

(c) Reaction with Carboxylic Acids—In presence of an acid (H_2SO_4 or HCl gas) ester is formed. This reaction is known as **esterification**.

$$\underset{\text{Ethanoic acid}}{CH_3C(=O)\ddot{-}OH} + \underset{\text{Ethanol}}{H\ddot{-}OC_2H_5} \overset{H^+}{\rightleftharpoons} \underset{\text{Ethyl ethanoate}}{CH_3COC_2H_5} + H_2O$$

Esterification is a reversible reaction. It can be pushed forward by using any of the reactants in large excess or by removing any of the products as soon as it is formed.

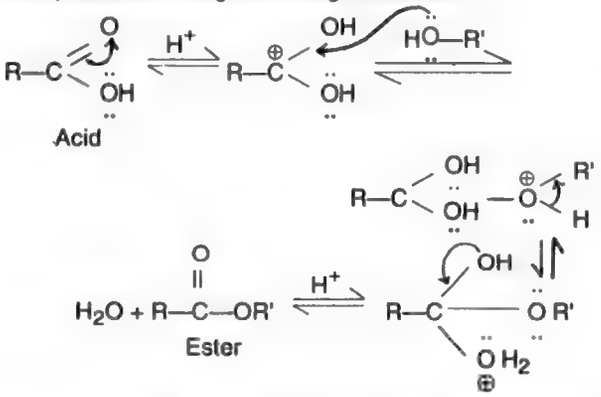
This reaction shows considerable **steric hindrance**. The bulkier the acid or alcohol, the slower the rate of esterification. For example :

$CH_3OH > CH_3CH_2OH > (CH_3)_2\,CHOH > (CH_3)_3C{-}OH$

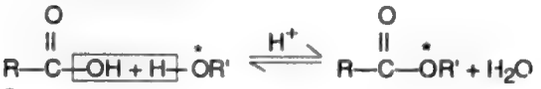
$HCOOH > CH_3COOH > (CH_3)_2\,CHCOOH > (CH_3)_3{-}CCOOH$

A Closer Look

- The esterification reaction of alcohols with carboxylic acid proceeds through following mechanism :



- Isotopic tracer technique shows that the esterification involves the cleavage of the O—H bond of alcohol and C—OH bond of acid :

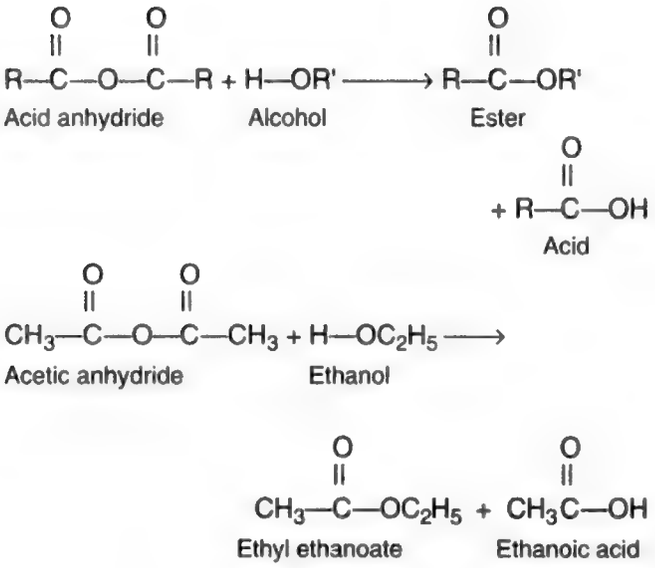


O is the radio isotope of oxygen.

(d) Reaction with Acid Halides or Acid Anhydrides—When treated with acid chloride or acid anhydride in the presence of bases like pyridine or dimethyl aniline (as catalyst) alcohols form esters. This reaction is called **acylation**.

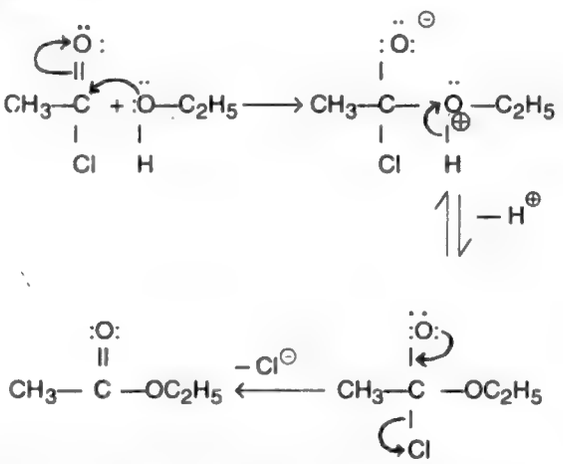
$$\underset{\text{Acid chloride}}{R{-}C(=O){-}Cl} + \underset{\text{Alcohol}}{H{-}OR'} \xrightarrow{\text{Base}} \underset{\text{Ester}}{R{-}C(=O){-}OR'} + HCl$$

$$CH_3{-}C(=O){-}Cl + H{-}OC_2H_5 \xrightarrow{\text{Base}} CH_3{-}C(=O){-}OC_2H_5 + HCl$$



Closer Look

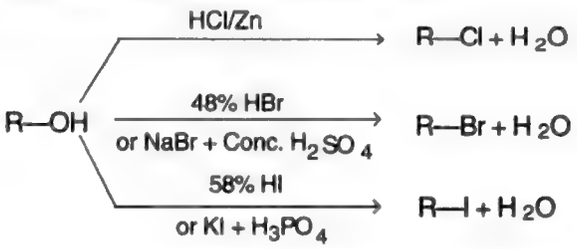
- Unlike the reactions with carboxylic acids, the reactions of alcohols with acid chlorides or acid anhydrides are **irreversible**. The yields of esters in these reactions are better than in the direct esterification with acids.
- The mechanistic path ways in these reactions are as follows :



- Since the net result in the above reaction is the replacement of hydrogen of the hydroxyl group of alcohol by acyl (RCO–) group, these reactions are referred to as **acylation reactions also**.

Reactions Involving Cleavage of C$\overset{\vdots}{-}$OH Bond :

(a) Reactions with Hydrogen Halides—The hydrogen halides react with alcohols to form alkyl halides. Various reactions are summarised below :



The order of reactivity of various alcohols is as :

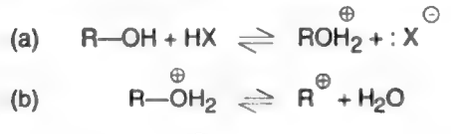
tertiary > secondary > primary alcohols.

The order of reacting hydrogen halides is as :

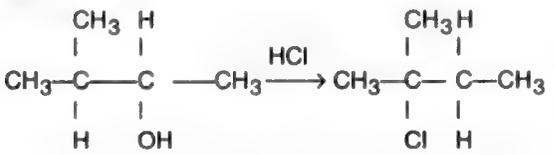
HI > HBr > HCl.

A Closer Look

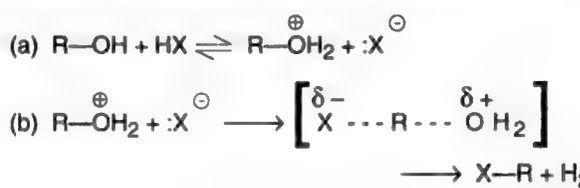
- Secondary and tertiary alcohols react with hydrogen halide through S_N1 reaction mechanism as :



- In step (a) : the alcohol accepts hydrogen ion to form protonated alcohol which dissociates into **carbocation** and water in step (b). The carbocation then combines with halide ion to form alkyl halide. In this sort of mechanism alkyl group of alcohol may undergo rearrangement due to rearrangement in the intermediate carbocation.



- Primary alcohols react through S_N2 mechanism as :



(b) Reactions with Phosphorus Halides—Alkyl halides are formed as :

$$R\text{–}OH + PCl_5 \longrightarrow R\text{–}Cl + POCl_3 + HCl\uparrow$$
Alcohol — Alkyl halide

$$C_2H_5OH + PCl_5 \longrightarrow C_2H_5Cl + POCl_3 + HCl\uparrow$$
Ethanol — Chloro ethane

$$3ROH + PX_3 \longrightarrow 3RX + H_3PO_3$$

$$3C_2H_5OH + PCl_3 \longrightarrow 3C_2H_5Cl + H_3PO_3$$

PBr_3 and PI_3 are generally prepared in situ by reaction between phosphorus bromine and iodine respectively.

$$3C_2H_5OH + PI_3 \xrightarrow{(P_4 + I_2)} 3C_2H_5I + H_3PO_3.$$

(c) Reaction with Thionyl chloride ($SOCl_2$)—Alcohols react with $SOCl_2$ in the presence of pyridine to form chloroalkanes.

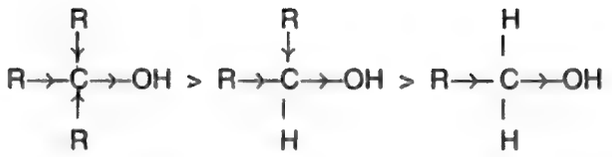
$$R\text{–}OH + SOCl_2 \xrightarrow{\text{Pyridine}} RCl + SO_2\uparrow + HCl\uparrow$$

$$C_2H_5OH + SOCl_2 \xrightarrow{\text{Pyridine}} C_2H_5Cl + SO_2\uparrow + HCl\uparrow$$
Ethanol — Thionyl Chloride — Chloroethane

The order of reactivity of various alcohols towards this type of reaction is :

tertiary > secondary > primary alcohols.

This can be explained in terms of electron releasing inductive effect of alkyl groups. The alkyl groups by their electron releasing effect tend to increase the electron displacement towards oxygen.



In other words, the polarity of C—O bond increases and this makes the breaking of the bond between carbon and oxygen easier. Therefore, the alcohols with greater number of alkyl groups attached to carbon will be more effective. This justifies the above order of reactivity of alcohols in this type of reactions.

Reactions Involving both Alkyl as well as Hydroxyl Groups :

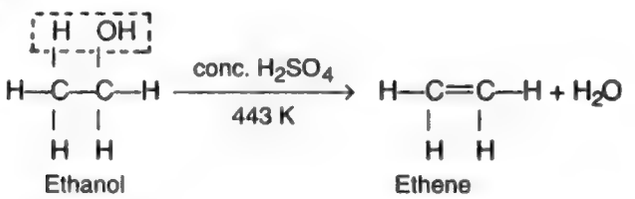
The important reactions of this type are :

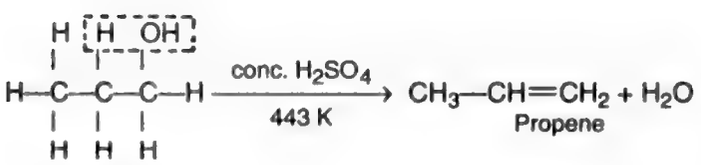
(a) Acidic Dehydration

(b) Oxidation

(c) Dehydrogenation

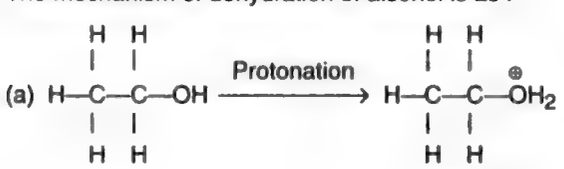
(a) Acidic Dehydration—When heated with concentrated H_2SO_4, phosphoric acid or boric acid, alcohols undergo dehydration to form alkenes. The reaction with concentrated H_2SO_4 is carried out at 443 K, whereas phosphoric acid and boric acid react at higher temperature.

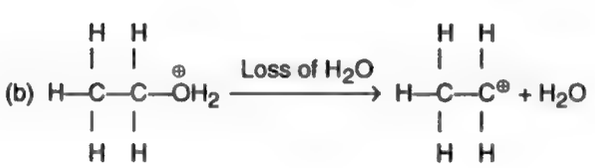


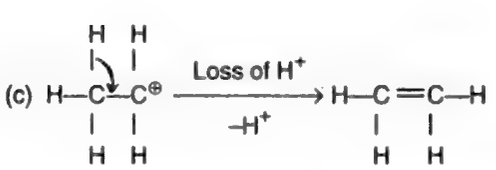


A Closer Look

- The mechanism of dehydration of alcohol is as :







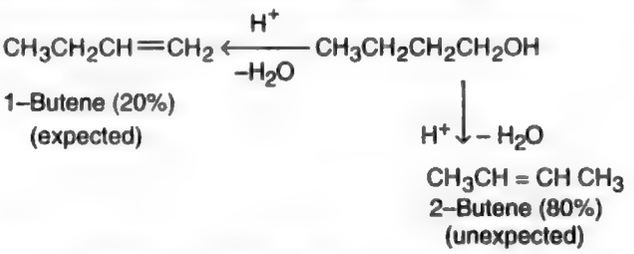
- **The relative ease of dehydration of alcohols**—Step (b) involving the formation of **carbocation** is slowest and rate-determining step. The more easily a carbocation is formed, the more easily that alcohol would dehydrate. Further, the greater the stability of a carbocation, the greater the ease with which it would be formed. Since the decreasing order of stability of carbocations is

tertiary > secondary > primary

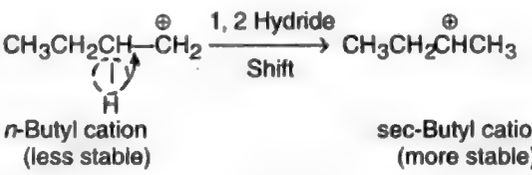
the decreasing order of dehydration of alcohols should be :

Tertiary > Secondary > Primary alcohols.

- **Formation of unexpected products**—Sometimes the alkenes containing double bonds at position different from those anticipated from the original position of the –OH group are formed in predominating amounts. For example.



Such migration of double bond is in agreement with the mechanism proposed for dehydration of alcohols. The carbocations always rearrange whenever, possible, to a stabler carbocation by **1, 2-hydride or alkyl shifts**. The primary, *n*-butyl cation will, therefore, rearrange to a more stable secondary butyl cation in above example and 2-butene rather than 1-butene is major product.



Dehydration of ethanol under different experimental conditions gives different products.

- At 383 K, ethyl hydrogen sulphate is obtained.

$$C_2H_5OH + H_2SO_4 \xrightarrow{383\ K} C_2H_5HSO_4 + H_2O$$

- Distillation under reduced pressure gives diethyl sulphate.

$$2C_2H_5OH + H_2SO_4 \xrightarrow{Heat} (C_2H_5)_2SO_4 + 2H_2O$$

- At 413 K, if alcohol is used in excess, the loss of H_2O molecule takes place from two different molecules of alcohol and ether is obtained as the product.

$$2C_2H_5OH \xrightarrow[413\ K]{Conc.\ H_2SO_4} C_2H_5OC_2H_5 + H_2O$$

(b) Oxidation of Alcohols—Alcohols undergo oxidation with oxidising agents (in neutral or acidic or alkaline medium) such as chromium trioxide (CrO_3), potassium dichromate ($K_2Cr_2O_7$), potassium permanganate ($KMnO_4$) and nitric acid.

- **Primary alcohols**—They are oxidised to carboxylic acids by potassium permanganate.

$$RCH_2OH + KMnO_4 \longrightarrow RCOOK + MnO_2 \downarrow + KOH$$

$$RCOOK + H^+ \longrightarrow RCOOH + K^+$$

An acidic solution of potassium dichromate can oxidise them to **aldehydes**, provided the products are dis-

tilled away as soon as they are formed. If the aldehyde formed continues to be available to the oxidant, carboxylic acids are formed ultimately.

$$RCH_2OH + Cr_2O_7^{2-} \longrightarrow R{-}\underset{\displaystyle H}{\overset{|}{C}}{=}O \xrightarrow{Cr_2O_7^{2-}} R{-}\underset{\displaystyle OH}{\overset{|}{C}}{=}O$$

Thus primary alcohols are oxidised to aldehydes and carboxylic acids containing the same number of carbon atoms as the original alcohol.

- **Secondary alcohols**—They are oxidised to ketones by chromic acid.

  $K_2Cr_2O_7 + H_2SO_4$ or $Cr_2O_3 + CH_3COOH$ or CrO_3 in (pyridine)

$$\underset{\text{A secondary alcohol}}{R_2CHOH} \xrightarrow{Cr_2O_7^{2-}} \underset{\text{Ketone}}{R_2C{=}O}$$

Ketones resist the further oxidation, but under vigorous conditions they are oxidised to a mixture of carboxylic acids. For example.

$$\underset{\text{Isopropyl alcohol}}{CH_3{-}\underset{\displaystyle OH}{\overset{|}{C}}H{-}CH_3} \longrightarrow \underset{\text{Acetic acid}}{CH_3COOH} + \underset{\text{Formic acid}}{HCOOH}$$

Thus, the ketones, the first stage oxidation products of sec. alcohols, contain same number of carbon atoms as original alcohols, but carboxylic acids contain fewer carbon atoms than the parent alcohol.

- **Tertiary Alcohols**—They are not oxidised under neutral or alkaline conditions, but acidic oxidising agents oxidise them, presumably, through the alkene formed under the acidic conditions, to a mixture of aldehydes, ketones and acids. For example :

$$\underset{\text{2-Methylpropane-2-ol}}{CH_3{-}\underset{\displaystyle CH_3}{\overset{|}{C}}(CH_3){-}OH} \xrightarrow{H^+} \underset{\text{2-Methylpropene}}{CH_3{-}\underset{\displaystyle CH_3}{\overset{|}{C}}{=}CH_2}$$

$$\xrightarrow{O} CH_3{-}\overset{\displaystyle CH_3}{\overset{|}{C}}{=}O + H{-}\overset{\displaystyle O}{\overset{||}{C}}{-}H \xrightarrow{O} CH_3COOH + HCOOH$$

Propanone, Methanal → HCOOH

- A variation of the above oxidation reaction is observed when vapours of an alcohol are passed over reduced copper at high temperature. The primary, secondary and tertiary alcohols give different products.

- **Primary alcohols**—They give aldehydes as :

$$R{-}\underset{\displaystyle H}{\overset{|}{C}}(H){-}OH \xrightarrow{Cu/575\ K} R{-}\overset{\displaystyle H}{\overset{|}{C}}{=}O + H_2\uparrow$$

- **Secondary alcohols**—They give ketones as :

$$R{-}\underset{\displaystyle H}{\overset{|}{C}}(R){-}OH \xrightarrow{Cu/575\ K} R{-}\overset{\displaystyle R}{\overset{|}{C}}{=}O + H_2\uparrow$$

- **Tertiary alcohols**—They do not undergo this type of reaction due to absence of α-hydrogen. However, it gets dehydrated to form an alkene.

$$\underset{\text{tert-Butyl alcohol}}{CH_3{-}\underset{\displaystyle CH_3}{\overset{|}{C}}(CH_3){-}OH} \xrightarrow{Cu/575\ K} \underset{\text{Isobutylene}}{CH_3{-}\overset{\displaystyle CH_3}{\overset{|}{C}}{=}CH_2} + H_2O$$

Since this oxidation reaction literally involves loss of hydrogen from alcohol, it is known as **catalytic dehydrogenation**. On the basis of products of oxidation, the distinction between primary, secondary and tertiary alcohols can be made.

More about the Distinction of Primary, Secondary and Tertiary alcohols

- **Lucas Test**—On treating with Lucas reagent (a mixture of conc. HCl and $ZnCl_2$), alcohols give cloudy appearance due to formation of alkyl chlorides. A tertiary alcohol reacts very fast, a secondary alcohol reacts within five minutes and a primary alcohol does not react appreciably at ordinary temperature.
- **Victor Meyer's Test**—The alcohol is subjected to the reaction sequence given below and the colours obtained are noted.

Primary alcohol	Secondary alcohol	Tertiary alcohol
RCH_2OH	R_2CHOH	$R_3C{-}OH$
$\downarrow P_4 + I_2$	$\downarrow P_4 + I_2$	$\downarrow P_4 + I_2$
RCH_2I	R_2CHI	R_3CI
$\downarrow AgNO_2$	$\downarrow AgNO_2$	$\downarrow AgNO_2$
RCH_2NO_2	R_2CHNO_2	$R_3C{-}NO_2$
$\downarrow HONO$	$\downarrow HONO$	$\downarrow HONO$
$R{-}\overset{\displaystyle N{-}OH}{\overset{\|}{C}}{-}NO_2$	$R{-}\overset{\displaystyle NO}{\overset{\|}{C}}(R){-}NO_2$	No reaction
Nitrolic acid	Pseudo nitrol	$\downarrow KOH$
$\downarrow KOH$	$\downarrow KOH$	
Red colour	Blue colour	Colourless

Some Important Alcohols :

(1) **Methyl alcohol or Methanol, CH_3OH**—It is manufactured by following methods :

(i) **From water gas**—

$$C + H_2O \text{ (steam)} \rightarrow \underbrace{CO + H_2}_{\text{Water gas}}$$

$$CO + 2H_2 \xrightarrow[300\text{–}400^\circ C/200 \text{ atm}]{CuO/ZnO/Cr_2O_3} CH_3OH$$

The crude methanol is fractionally distilled. This method gives methanol of excellent purity and in excellent yield.

(ii) **From natural gas**—Controlled air oxidation of marsh gas by passing its mixture with oxygen (9 : 1) through a copper tube at 200°C, under a pressure of 100 atm. gives methanol.

$$CH_4 + \frac{1}{2}O_2 \xrightarrow[200^\circ C/100 \text{ atm}]{Cu \text{ tube}} CH_3OH$$

(iii) **From Pyroligneous Acid**—This is also referred to as destructive distillation of wood.

Wood

Destructive Distillation at 400°C

↓

Volatile Gases Passed into condenser — Non-volatile residue (Wood charcoal)

Volatile Gases Passed into condenser →

Uncondensed gases (Wood gases used as fuel) (CO, CH_4, C_2H_4, C_2H_6, H_2 etc.)

Distillate allowed to settle →

Upper aqueous layer Pyroligneous acid (Acetic acid, Methanol, Acetone) 10% 2-4% 0·5%

Lower layer Wood Tar (A mixture of cresols, used for preservation of timber under the name of creosote)

The aqueous layer is distilled and the vapour is passed over milk of lime. Acetic acid is retained as calcium acetate, but methanol, acetone and other volatile compounds pass over as **wood spirit**. The wood spirit is then fractionally distilled to give a low boiling fraction, a crude methanol fraction and a higher boiling fraction containing a mixture of alcohols and ketones. The crude methanol fraction is then carefully refractionated to give pure methanol.

Purification :

Methanol obtained from pyroligneous acid is treated with anhydrous $CaCl_2$, when crystalline derivative, $CaCl_2 \cdot 4CH_3OH$ is formed, leaving acetone unaffected. The crystals are filtered and boiled with water when alcohol is regenerated. This is distilled. To remove last trace of water, the distillate is dried over quick lime.

In another method, impure methanol is treated with oxalic acid when solid methyl oxalate is obtained. This is filtered off, boiled with calculated amount of caustic potash and distilled. Pure methyl alcohol distills over at 65°C. It is dried over quick lime.

$$\underset{\text{Oxalic acid}}{\begin{matrix}COOH\\|\\COOH\end{matrix}} + 2CH_3OH \rightarrow \underset{\text{Methyl oxalate}}{\begin{matrix}COOCH_3\\|\\COOCH_3\end{matrix}} \xrightarrow{2KOH} \begin{matrix}COOK\\|\\COOK\end{matrix} + 2CH_3OH$$

Uses of methyl alcohol—It has following important uses :

(i) Methanol is an important source material for the production of formaldehyde. Formaldehyde is a raw material for plastic industry.

(ii) Important chemicals like methylaniline, dimethylaniline, methyl chloride, dimethyl sulphate, methyl salicylate, terylene, polyvinyl alcohol etc. are manufactured from methanol.

(iii) Methanol is used for denaturing alcohol rendering it unfit for drinking.

(iv) Methanol finds application in antifreeze composition for automobile and aeroplane radiators.

(v) Methanol finds important place as a solvent in many industrial processes, in certain adhesive compositions and in wood stains.

(vi) It is also used as component of motor spirit blends.

(2) **Ethyl Alcohol or Ethanol, C_2H_5OH**—It is manufactured by following methods :

(i) **Fermentation of Carbohydrates**—Molasses and starchy materials are two important raw materials for large scale preparation of ethyl alcohol. Fermentation is actually decomposition of organic compounds into simpler compounds through the agency of enzymes, the biocatalysts. In commerce the ethyl alcohol is known as **spirit of wine** or **grain alcohol**.

(a) **From Molasses**—Molasses, the mother liquor left after the crystallisation of cane-sugar from sugar-cane juice, is diluted with water to reduce the concentration of sugar to about 10 percent, sterilised by heating with live steam for a short time and acidified with sulphuric acid to pH = 4. This checks the growth of any undesirable bacteria. Suitable quantities of ammonium sulphate and ammonium phosphate may be added which act as supplementary food for yeast. The liquid (wort) so obtained, is placed in a large fermentation tank, maintained at the temperature of about 35°C. In the presence of yeast culture, fermentation starts accompanied by the following reactions :

(i) The enzyme, **invertase** present in yeast converts sucrose into glucose and fructose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{(Yeast)}]{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

(ii) The enzyme **Zymase**, further converts the glucose and fructose into ethyl alcohol and carbon dioxide.

$$C_6H_{12}O_6 \xrightarrow[\text{(Yeast)}]{\text{Zymase}} 2C_2H_5OH + 2CO_2 \uparrow$$

When the alcohol content of fermented liquor rises to about 15%, the yeast cells are killed and the process of fermentation stops. The liquor thus obtained is subjected to fractional distillation to get following fractions :

First runnings—These consist of acetaldehyde and are used as an important source of acetaldehyde.

Rectified spirit or **Industrial alcohol**—This consists of 93 – 95 per cent of ethyl alcohol.

Final runnings or Fusel oil—This is obtained between temperature range 125 – 140°C and is a mixture of:

n-propyl, *n*-butyl, isobutyl, *n*-amyl, isoamyl and active amyl alcohols.

It must be noted that these alcohols are not produced by the fermentation of sugar but are formed by the action of yeast on certain amino acids obtained from the proteins present in raw materials.

(b) **From Starch**—The starchy materials like potatoes, maize, barley, rice etc. are used. The production of ethanol from starchy materials can be outlined as follows :

(i) **Malting**—Barley moistened with water and spread in a room in layers about five inches thick, is allowed to germinate in the dark at about 15°C. After suitable time the germination is stopped by heating the barley to about 60°C. This germinated product is known as **malt**.

(ii) **Liberation of starch**—The malt is crushed and treated with steam at 140 – 150°C under pressure when the starch present in the malt is brought into solution. This solution is known as **mash**.

(iii) **Saccharification**—Malt is added to the mash and is kept at 50°C. The enzyme, **diastase** present in malt converts the starch into **maltose**.

$$\underset{\text{Starch}}{(C_6H_{10}O_5)_n} + n/2\ H_2O \xrightarrow[(\text{Malt})]{\text{Diastase}} n/2\ \underset{\text{Maltose}}{C_{12}H_{22}O_{11}}$$

In an alternative method, starch may be converted into glucose by heating with dilute sulphuric acid or hydrochloric acid, and the excess of acid is neutralised by adding lime.

$$\underset{\text{Starch}}{(C_6H_{10}O_5)_n} + n\,H_2O \longrightarrow n\,\underset{\text{Glucose}}{C_6H_{12}O_6}$$

(iv) **Fermentation**—The maltose solution, obtained in step (iii) is cooled to about 30°C and fermented as usual by yeast for 3 days, when the following reaction occurs :

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[(\text{Yeast})]{\text{Maltase}} 2\underset{\text{Glucose}}{C_6H_{12}O_6}$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[(\text{Yeast})]{\text{Zymase}} \underset{\text{Ethyl alcohol}}{2C_2H_5OH} + 2CO_2\uparrow$$

The fermented liquor contains about 10 percent alcohol and is subjected to fractional distillation to industrial alcohol.

By-products of Alcoholic Fermentation—Following are important by-products of alcoholic fermentation :

(i) **Acetaldehyde**

(ii) **Fusel oil**

(iii) **Carbon dioxide**—Compressed in iron cylinders used in aerated water industry or as a dry ice.

(iv) **Spent wash**—It is the solid mass left after distillation of various fractions, and is used as a Cattle Feed.

Absolute Alcohol—Ethyl alcohol forms a constant boiling mixture *i.e.*, azeotrope, containing 95·87% by weight of alcohol with water. Since this mixture boils at 78·15°C, a temperature slightly lower than the boiling point of pure ethanol (78·3°C), it is not possible to effect a complete separation of ethyl alcohol from water by fractional distillation alone. Alcohol containing only 0·8% water (lime alcohol) can be prepared by distilling rectified spirit repeatedly over fresh quick lime. The last trace of water is removed by distilling the lime-alcohol over a requisite amount of metallic sodium or magnesium or calcium.

On large scale the absolute alcohol is prepared by the **azeotropic distillation** of industrial alcohol. In this method the advantage is taken of the fact that alcohol forms a **ternary** constant boiling mixture with water and benzene.

Water = 7·5%

Alcohol = 18·5%

Benzene = 74·0% by w/W

This mixture boils at 64·9°C. The industrial alcohol which contains 4·13% water is mixed with benzene, sufficient enough to form a ternary constant boiling mixture with almost the entire amount of water present and then distilled. The ternary azeotrope distils at 64·9°C carrying entire water present and absolute alcohol is left behind which is totally free from water and benzene.

Absolute alcohol blended with petrol in the ratio of 20%, is used as a motor fuel, hence it is named as **power alcohol** also.

Uses of Ethyl Alcohol—Following are important uses of ethyl alcohol :

(i) Ethyl alcohol is important component of alcoholic Beverages.

For example :

Beer contains 3 – 5% of ethyl alcohol

Cider contains 2 – 4% of ethyl alcohol

Gin contains 35 – 40% of ethyl alcohol

Brandy contains 35 – 40% of ethyl alcohol

Whisky contains 35 – 40% of ethyl alcohol

Rum contains 35 – 40% of ethyl alcohol

(ii) Ethanol is used as a solvent for gums, resins, paints, varnishes, stains, pharmaceutical products, perfumes, flavourings etc.

(iii) Ethyl alcohol is used for the preparation of acetaldehyde, acetic acid, acetic anhydride, esters, chloral, chloroform etc.

(iv) Biological specimen are preserved in ethanol.

(v) Ethanol is used as a low freezing and mobile liquid in scientific equipments like thermometers, spirit levels etc.

(vi) It is used as a component of fuels (power alcohol) for the internal combustion engines in many countries.

(vii) It is also used as ethylating agent in the manufacture of dye intermediates, drugs etc.

Points to Remember

- The strength of an alcohol preparation is expressed in the terms of **proof spirit**. Proof spirit is the aqueous ethyl alcohol containing 57·1% by volume of ethyl alcohol. The sample is referred to as over-proof or under-proof according as it is stronger or weaker than proof-spirit.

  A 20° under-proof sample means that 100 volumes of the sample contain as much alcohol as 80 volumes of proof-spirit. Similarly 20° over-proof sample is one whose 100 volumes contain as much alcohol as 120 volumes of proof-spirit.
- The terms **distilled** and **undistilled** are used in describing alcoholic beverages. The undistilled beverages, which have low alcoholic content, are generally prepared by **fermentation** of fruit juices. The distilled beverages containing much higher alcoholic contents are made by distillation of fermented liquors.
- Since ethanol can be used for drinking purposes, it is heavily taxed. But the ethanol used for industrial purposes is duty free. In order to make industrial alcohol unfit for drinking, it is **denatured** by mixing poisonous substances like methanol, acetone, rubber thinner, and pyridine or bone oil. Such a denatured alcohol is known as **methylated spirit**.
- Mineralised methylated spirit is coloured and is made by adding 0·5 part by volume of crude pyridine and 9·5 parts by volume of methanol to 90 parts by volume of **rectified spirit** (95·5% ethanol) and adding to every 100 gallons of resulting mixture not less than 3/8 of a gallon of **mineral naphtha** and not less than 1/40 oz. of the dye methyl violet.

  Following are important applications of fermentation :

  (i) Manufacture of ethyl alcohol from sugars and starch.

  (ii) Preparation of alcoholic beverages from fruit juices.

  (iii) Preparation of glycerol from sugar solution in the presence of Na_2SO_3.

  (iv) Preparation of acetone and butyl alcohol from starch by the activity of **clostridium aceto butylicum** bacteria.

  (v) Preparation of vinegar from ethyl alcohol by the activity of the mycoderma aceti.

  $$C_2H_5OH + 2[O] \xrightarrow{\text{Mycoderma aceti}} CH_3COOH + H_2O$$

  (vi) Preparation of lactic acid from lactose, sucrose, maltose or glucose.

  $$C_6H_{12}O_6 \xrightarrow{\text{Lactic bacilli}} \underset{\text{Lactic acid}}{2CH_3CH(OH)COOH}$$

  (vii) Preparation of citric acid from molasses or glucose or sucrose by the activity of **Aspergillus niger**.
- A few common enzymes with their sources and functions are given as :

Enzyme	Source	Function	Type of reaction
Diastase	Malt (Germinated barley)	Starch → Maltose	Hydrolysis
Maltase	Yeast	Maltose → Glucose	Hydrolysis
Zymase	Yeast	Glucose and fructose → Ethanol + CO_2	Decomposition
Invertase	Yeast	Cane-sugar → Glucose + Fructose	Hydrolysis
Urease	Soyabean	Urea → $NH_3 + CO_2$	Hydrolysis

- In 1860, the pioneer worker **Pasteur** suggested that fermentation is purely a physiological process carried out by living micro-organisms. However, **Liebig** considered it to be purely a chemical reaction. **Buchner** (1897) showed that the presence of living cells is not necessary for this reaction. Thus the truth regarding the nature of fermentation lies between the views of Pasteur and Liebig.

  The fermentation is slow decomposition of complex organic compounds by the activity of non-living complex nitrogenous substances (enzymes) produced in living organisms.
- When acetylene is passed into 42% H_2SO_4 containing 1% $HgSO_4$ at 60°C, acetaldehyde is forme Acetaldehyde on reduction gives ethyl alcohol.

  $$\begin{matrix}CH\\ \|\\ CH\end{matrix} + H_2O \xrightarrow[\Delta(60°C)]{42\%\ H_2SO_4 + 1\%\ HgSO_4} \left[\begin{matrix}CH_2\\ \|\\ CHOH\end{matrix}\right] \rightarrow CH_3CHO$$

  $$CH_3CHO + H_2 \xrightarrow[110° - 140°C]{Ni} \underset{\text{Ethanol}}{CH_3CH_2OH}$$
- Relative acidity of various common compounds is as :

  $R–COOH > H_2CO_3 > C_6H_5OH > HOH > ROH$
- Alcohols show following kinds of isomerism :

  (i) **Chain isomerism :**

  $CH_3CH_2CH_2CH_2OH$ and $CH_3–\underset{\displaystyle CH_3}{\underset{|}{CH}}–CH_2OH$

  n-Butanol — Isobutyl alcohol

  (ii) **Position isomerism :**

  $CH_3CH_2CH_2OH$ and $CH_3–\underset{\displaystyle OH}{\underset{|}{CH}}–CH_3$

  Propyl alcohol — Isopropyl alcohol

  (iii) **Functional isomerism :**

  $CH_3CH_2CH_2CH_2OH$ and $C_2H_5OC_2H_5$

  n-Butanol — Diethyl ether

OBJECTIVE QUESTIONS

1. The number of alcohol isomers arrived at from molecular formula $C_4H_{10}O$ is—
   (A) 2 (B) 3
   (C) 4 (D) 5

2. When equimolar quantities of ethanol and methanol are mixed and heated with conc. H_2SO_4, the product formed is—
   (A) $C_2H_5OC_2H_5$
   (B) CH_3OCH_3
   (C) $C_2H_5OCH_3$
   (D) All of these

3. The alcohol which reacts fastest with Luca's reagent at normal temperature is—
   (A) 2–Methyl propane–1–ol
   (B) 2–Methyl propane–2–ol
   (C) Butane–1–ol
   (D) Butane–2–ol

4. Which of the following compounds can be used for the preparation of chloroform ?
   (A) $CH_3CH_2COC_3H_7$
   (B) $CH_3COC_2H_5$
   (C) $CH_3CH_2COCH_2CH_3$
   (D) All of these

5. Ethanol when heated with conc. H_2SO_4 may give—
   (A) Diethyl sulphate only
   (B) Diethyl ether only
   (C) Ethylene only
   (D) All of these

6. The compound which is not isomeric with diethyl ether is—
   (A) Butane–1-ol
   (B) *n*-Propylmethyl ether
   (C) 2–Methyl propane-2-ol
   (D) None of these

7. Denatured spirit is mainly used as a—
   (A) Medicine
   (B) Good fuel
   (C) Solvent
   (D) Component of beverages

8. An organic compound when passed over heated copper at 575 K, gives an alkene, the compound is—
   (A) Alkane
   (B) Akyne
   (C) Secondary alcohol
   (D) Tertiary alcohol

9. Which of the following compounds has highest boiling point ?
   (A) Ethanol
   (B) Methoxymethane
   (C) Chloromethane
   (D) Propane

10. Which of the following bonds of an alcohol is cleaved when it reacts with carboxylic acids ?
    (A) C—H
    (B) C—O
    (C) O—H
    (D) All of these

11. Which of the following alcohols cannot be dehydrogenated ?
    (A) $CH_3CH_2CH_2CH_2OH$
    (B) $CH_3\underset{\displaystyle OH}{\underset{|}{C}}H—CH_2CH_3$
    (C) $(CH_3)_3COH$
    (D) $(CH_3)_2CHOH$

12. In the reaction sequence

$$X \xrightarrow{HBr} CH_3—\underset{\displaystyle Br}{\underset{|}{C}}H—CH_3 \xrightarrow{alc.KOH}$$

$$Y \xrightarrow[Peroxide]{HBr} Z$$

    X, Y and Z are respectively—
    (A) 2–Propanol, Propene, 1–Bromopropane
    (B) Propene, 2–Bromopropane, Propene
    (C) 2–Propanol, Propyne, 2–Bromopropane
    (D) 1–Propanol, Propene, 1–Bromopropene

13. An organic compound (A) gives positive Lucas test in 5 minutes. When 6·0 gm of (A) is treated with sodium metal, 1120 ml of hydrogen is evolved at STP. The organic compound is—
    (A) $CH_3CH_2—\underset{\displaystyle OH}{\underset{|}{C}}H—CH_3$
    (B) $CH_3—\underset{\displaystyle OH}{\underset{|}{C}}H—CH_3$
    (C) $CH_3—\underset{\displaystyle CH_3}{\underset{|}{\overset{\displaystyle CH_3}{\overset{|}{C}}}}—OH$
    (D) CH_3CH_2OH

14. Which of the following alcohols can be obtained from HCHO ?
    (A) CH_3OH
    (B) C_2H_5OH
    (C) $CH_3CH_2CH_2OH$
    (D) All of these

15. Phenol can be distinguished from ethyl alcohol by all reagents except—
    (A) NaOH (B) $FeCl_3$
    (C) Br_2/H_2O (D) Na

16. Alcohol can be obtained by all methods except—
    (A) Hydroboration–oxidation
    (B) Oxymercuration–demercuration
    (C) Reduction of aldehydes with Zn-Hg/HCl
    (D) By fermentation of starch

17. Which of the following alcohols is least soluble in water ?
    (A) *n*-Butyl alcohol
    (B) Iso-Butyl alcohol
    (C) Tert-Butyl alcohol
    (D) Sec-Butyl alcohol

18. Which of the following compounds is isomeric with 1-Propanol ?
    (A) Ethanol
    (B) 2–Methyl–2–Propanol
    (C) 1–Butanol
    (D) Ethyl-methyl ether

19. Which of the following compounds would yield carboxylic acid as the product on oxidation with acidified $K_2Cr_2O_7$?
    (A) 1–Butanol
    (B) 1–Propanol
    (C) Both
    (D) None of these

20. Which one of the following can convert 2–Propanol to acetone ?
    (A) $K_2Cr_2O_7/H^+$
    (B) Cu/575 K

(C) Both
(D) None of these

21. The enzyme which converts glucose and fructose into ethyl-alcohol is—
(A) Diastase (B) Invertase
(C) Zymase (D) Maltase

22. A solution of ethyl alcohol—
(A) Decolourises the litmus paper
(B) Changes red litmus blue
(C) Changes blue litmus red
(D) Does not affect litmus paper

23. On industrial scale ethanol is manufactured by the fermentation of—
(A) $C_6H_{12}O_6$ (B) CH_3COOH
(C) Molasses (D) $C_{12}H_{22}O_{11}$

24. The percentage of ethyl alcohol in rectified spirit is—
(A) 75·00 (B) 85·5
(C) 95·6 (D) 100·0

25. Which of the following alcohols will be most acidic ?
(A) CH_3OH (B) $R–CH_2OH$
(C) R_2CHOH (D) R_3COH

26. Dehydration of ethanol cannot give—
(A) $C_2H_5OC_2H_5$
(B) $C_2H_5HSO_4$
(C) C_2H_4
(D) C_2H_2

27. An alcohol on oxidation gives CH_3COOH and CH_3CH_2COOH, the alcohol is—
(A) $CH_3CH(OH)\ CH_2CH_2CH_3$
(B) $CH_3(CH_2)_2CHOH$
(C) $(CH_3)_2\ C(OH)\ CH_2CH_3$
(D) $CH_3CH_2CH_2OH$

28. Which of the following compounds gives a positive iodoform test ?
(A) 3–Pentanol
(B) 2–Phenyl-ethanol
(C) 1–Phenyl ethanol
(D) Pentanal

29. Determination of percentage of alcohol in wine is called—
(A) Iodometry
(B) Iodimetry
(C) Alcoholometry
(D) Acidometry

30. Formation of 2–butene as major product by dehydration of 2–butanol is according to—
(A) Saytzeff rule
(B) Peroxide effect
(C) Markownikoff's rule
(D) Anti-Markownikoff's rule

31. Primary, secondary and tertiary alcohols are distinguished by—
(A) Oxidation
(B) Lucas reagent
(C) Victor Meyer method
(D) All of these

32. Which will respond to iodoform test ?
(A) CH_3OH
(B) $(CH_3)_3C·CHO$
(C) $(CH_3)_2CHOH$
(D) $CH_3CH_2CH_2OH$

33. The percentage of ethanol by weight in proof spirit is—
(A) 90 (B) 10
(C) 48 (D) 4·5

34. Fermentation of starch solution to ethanol does not require—
(A) Maltase (B) Diastase
(C) Invertase (D) Zymase

35. The correct order of boiling point of alcohols having comparable molar mass is—
(A) $1° < 2° < 3°$
(B) $3° < 2° < 1°$
(C) $2° < 1° < 3°$
(D) None is correct

36. The —OH group of CH_3OH can not be replaced by the chlorine by the action of—
(A) HCl (B) PCl_3
(C) PCl_5 (D) Cl_2

37. Which of the following compounds is known as wood spirit ?
(A) Wood tar
(B) Methanol
(C) Ethanol
(D) 95% ethanol

38. Cyclohexanol is a—
(A) Phenol
(B) Primary alcohol
(C) Secondary alcohol
(D) Tertiary alcohol

39. During the dehydration of alcohols, the ease of formation of carbocation follows the order—
(A) $1° > 2° > 3°$
(B) $3° > 2° > 1°$
(C) $3° > 1° > 2°$
(D) $2° > 1° > 3°$

40. C_2H_5OH can be distinguished from CH_3OH—
(A) By the action of HCl
(B) By the action of NH_3
(C) By determining the solubility in water
(D) By iodoform test

ANSWERS

1. (C) 2. (D) 3. (B) 4. (B) 5. (D)
6. (D) 7. (C) 8. (D) 9. (A) 10. (C)
11. (C) 12. (A) 13. (B) 14. (D) 15. (D)
16. (C) 17. (A) 18. (D) 19. (C) 20. (C)
21. (C) 22. (D) 23. (C) 24. (C) 25. (A)
26. (D) 27. (A) 28. (C) 29. (C) 30. (A)
31. (D) 32. (C) 33. (C) 34. (C) 35. (B)
36. (D) 37. (B) 38. (C) 39. (B) 40. (D)

●●●

FORM 4
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Signature of Publisher

CHEMISTRY

1. The electrons identified by quantum numbers n and l—
   (i) $n = 4, l = 1$
   (ii) $n = 4, l = 0$
   (iii) $n = 3, l = 2$
   (iv) $n = 3, l = 1$ can be placed in order of increasing energy, from the lowest to highest as
   (A) (iv) < (ii) < (iii) < (i)
   (B) (ii) < (iv) < (i) < (iii)
   (C) (i) < (iii) < (ii) < (iv)
   (D) (iii) < (i) < (iv) < (ii)

2. The number of neutrons accompanying the formation of $_{54}Xe^{139}$ and $_{38}Sr^{94}$ from the absorption of a slow neutron by $_{92}U^{235}$, followed by nuclear fission is—
   (A) 0 (B) 2
   (C) 1 (D) 3

3. Molar heat capacity of water in equilibrium with ice at constant pressure is—
   (A) Zero
   (B) Infinity
   (C) 40·45 kJ K^{-1} mol^{-1}
   (D) 75·48 K^{-1} mol^{-1}

4. Standard molar enthalpy of formation of CO_2 is equal to—
   (A) Zero
   (B) The standard molar enthalpy of combustion of gases carbon
   (C) The sum of standard molar enthalpies of formation of CO and O_2
   (D) The standard molar enthalpy of combustion of carbon (graphite)

5. A gas will approach ideal behaviour at—
   (A) Low temperature and low pressure
   (B) Low temperature and high pressure
   (C) High temperature and low pressure
   (D) High temperature and high pressure

6. The normality of 0·3 M phosphorous acid (H_3PO_3) is—
   (A) 0·1 (B) 0·9
   (C) 0·3 (D) 0·6

7. The pH of 0·1M solution of following salts increases in the order—
   (A) NaCl < NH_4Cl < NaCN < HCl
   (B) HCl < NH_4Cl < NaCl < NaCN
   (C) NaCN < NH_4Cl < NaCl < HCl
   (D) HCl < NaCl < NaCN < NH_4Cl

8. On heating ammonium dichromate the gas evolved is—
   (A) Oxygen
   (B) Ammonia
   (C) Nitrous oxide
   (D) Nitrogen

9. In the commercial electrochemical process for aluminium extraction the electrolyte used is—
   (A) $Al(OH)_3$ and NaOH solution
   (B) An aqueous solution of $Al_2(SO_4)_3$
   (C) A molten mixture of Al_2O_3 and Na_3AlF_6
   (D) A molten mixture of AlO(OH) and $Al(OH)_3$

10. In the compound
    $CH_2{=}CH{-}CH_2{-}CH_2{-}C{\equiv}CH$
    the C_2—C_3 bond is of the type—
    (A) sp–sp^2 (B) sp^3–sp^3
    (C) sp–sp^3 (D) sp^2–sp^3

11. Which one of the following has the smallest radius ?
    (A) Na^+ (B) Li^+
    (C) Be^{2+} (D) Mg^{2+}

12. Which one of the following does not cause hardness of water ?
    (A) $CaCl_2$ (B) $MgSO_4$
    (C) Na_2SO_4 (D) $Ca(HCO_3)_2$

13. Which one of the following does not contain —COOH group ?
    (A) Picric acid
    (B) Asprin
    (C) Benzoic acid
    (D) Ethanoic acid

14. The first ionisation potential of N and O are (in eV) respectively—
    (A) 14·6, 13·6 (B) 13·6, 14·6
    (C) 13·6, 13·6 (D) 14·6, 14·6

15. How many grams of CH_3OH would have to be added to water to prepare 150 ml of a solution that is 2·0 M CH_3OH ?
    (A) $9{\cdot}6 \times 10^3$ gram
    (B) $4{\cdot}3 \times 10^2$ gram
    (C) 9·6 gram
    (D) 24 gram

16. In which of the following Markownikoff's rule is applicable ?
    (A) $CH{\equiv}CH$
    (B) $CH_3{-}C{\equiv}CH$
    (C) $CH_3{-}CH_2{-}HC{=}CH_2$
    (D) None of these

17. Among the following species, identify the isostructural pairs—
    NF_3, NO_3^-, BF_3, H_3O^+, HN_3
    (A) [NF_3, NO_3^-] and [BF_3, H_3O^+]
    (B) [NF_3, HN_3] and [NO_3^-, BF_3, H_3O^+]
    (C) [NF_3, H_3O^+] and [NO_3^-, BF_3]
    (D) [NF_3, H_3O^+] and [HN_3, BF_3]

18. A monoprotic acid is 1 M solution. Its degree of dissociation is 0·001%. Calculate the dissociation constant—
    (A) $1{\cdot}0 \times 10^{-10}$
    (B) $1{\cdot}0 \times 10^{-5}$
    (C) $1{\cdot}0 \times 10^{-11}$
    (D) $1{\cdot}0 \times 10^{-3}$

19. The standard reduction potential values of three metallic cations X, Y, Z are 0·52, −3·03 and −1·18 V respectively. The order of reducing power of the corresponding metals is—
    (A) Y > Z > X
    (B) X > Y > Z
    (C) Z > Y > X
    (D) Z > X > Y

20. The energy of an electron in the Bohr orbit of H-atom is − 13·6 eV. The possible energy value of an excited state for electron in Bohr orbit of hydrogen is—
    (A) −3·4 eV (B) −4·2 eV
    (C) − 6·8 eV (D) + 6·8 eV

21. White phosphorous (P_4) does not contain—
(A) Six P-P single bonds
(B) Four P-P single bonds
(C) Four lone pairs of electrons
(D) PPP angle of 60°

22. Which of the following statement is not correct when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4 ?
(A) A deep red vapour is evolved
(B) The vapour when passed into NaOH solution gives a yellow solution of Na_2CrO_4
(C) Cl_2 gas is evolved
(D) Chromyl chloride is formed

23. Benzene-diazonium chloride on reaction with phenol in weakly basic medium gives—
(A) Diphenyl ether
(B) *p*-hydroxyazobenzene
(C) Chlorobenzene
(D) Benzene

24. The O. P. of a solution is given by the relation—
(A) $\pi = ST/C$ (B) $\pi = \frac{CT}{S}$
(C) $\pi = \frac{SC}{T}$ (D) $\pi = CST$

25. Empirical formula of an organic compound is CH_2, Mass of 1 mole of it is 42 g. The molecular formula of the compound is—
(A) C_4H_8 (B) C_3H_6
(C) C_2H_4 (D) CH_2

26. Liquid benzene burns in oxygen according to—

$$2C_6H_{6\,(l)} + 15O_{2(g)} \rightarrow 12\,CO_{2\,(g)} + 6\,H_2O_{(g)}$$

How many litre of O_2 at STP are needed to complete the combustion of 39g of liquid benzene ?
(A) 11·2 litre (B) 22·4 litre
(C) 84 litre (D) 74 litre

27. Which of the following sodium compound/compounds are formed when an organic compound containing both nitrogen and sulphur is fused with sodium ?
(A) Cyanide and sulphide
(B) Thiocyanate
(C) Sulphite and cyanide
(D) Nitrate and sulphide

28. Zinc copper couple that can be used as a reducing agent is obtained by—
(A) Mixing Zn dust and copper gauze
(B) Zinc coated with copper
(C) Copper coated with zinc
(D) Zinc and copper wires welded together

29. The compound which is used in refrigeration is—
(A) CF_4 (B) CCl_4
(C) $COCl_2$ (D) CCl_2F_2

30. The bad smelling substance formed by action of alcoholic caustic potash on chloroform and aniline is—
(A) Phenylisocyanide
(B) Nitrobenzene
(C) Chloropicrin
(D) Acetylene

31. Which one is primary alcoholic group ?
(A) $-CH_2OH$
(B) $>CHOH$
(C) $>C-OH$
(D) $>\underset{|}{\overset{OH}{C}}-\underset{|}{\overset{OH}{C}}<$

32. A compound X on heating gives a colourless gas. The residue is dissolved in water to obtain Y. Excess CO_2 is bubbled through aqueous solution of Y, Z is formed. Z on gentle heating gives back X. The compound X is—
(A) $CaCO_3$ (B) Na_2CO_3
(C) $Ca(HCO_3)_2$ (D) K_2CO_3

33. The hydration energy of Mg^{2+} ion is higher than that of—
(A) Al^{3+} (B) Be^{2+}
(C) Na^+ (D) None of these

34. Which one of the following is most acidic ?
(A) Na_2O (B) MgO
(C) Al_2O_3 (D) CaO

35. Three centered bond is present in—
(A) NH_3 (B) B_2H_6
(C) BCl_3 (D) $AlCl_3$

36. A dry ice piece is composed of—
(A) Solid He (B) Solid CO_2
(C) Solid SO_2 (D) Solid C_6H_6

37. A gaseous mixture contains O_2 and N_2 in the ratio 1 : 4 by mass. The ratio of their molecules is—
(A) 1 : 4 (B) 1 : 8
(C) 3 : 6 (D) 7 : 32

38. Which of the following fluorides does not exist ?
(A) NF_5 (B) PF_5
(C) AsF_5 (D) SbF_5

39. Which of the following molecule does not possess a permanent dipole moment ?
(A) H_2S (B) SO_2
(C) H_2O (D) CS_2

40. Among $Ni(CO)_4$, $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$—
(A) $Ni(CO)_4$ and $[NiCl_4]^{2-}$ are diamagnetic and $[Ni(CN)_4]^{2-}$ is paramagnetic
(B) $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $Ni(CO)_4$ is paramagnetic
(C) $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $[NiCl_4]^{2-}$ is paramagnetic
(D) $Ni(CO)_4$ is diamagnetic and $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ are paramagnetic

41. The orbital angular momentum of an electron in 2*s* orbital is—
(A) $+\frac{1}{2}\frac{h}{2\pi}$ (B) Zero
(C) $\frac{h}{2\pi}$ (D) $\sqrt{2}\frac{h}{2\pi}$

42. The decay constant of ^{226}Ra is $1{\cdot}37 \times 10^{-11}$ sec^{-1}. A sample of ^{226}Ra having an activity of 1·5 milli curie will contains ..... atoms.
(A) $4{\cdot}05 \times 10^{18}$
(B) $3{\cdot}7 \times 10^{17}$
(C) $2{\cdot}05 \times 10^{15}$
(D) $4{\cdot}7 \times 10^{10}$

43. Which substance serving as reducing agent in the following reaction ?

$$Cr_2O_7^{2-} + 14H^+ + 3Ni \rightarrow 2Cr^{3+} + 7H_2O + 3Ni^{2+}$$

(A) H_2O (B) Ni
(C) H^+ (D) $Cr_2O_7^{2-}$

44. Given standard electrode potentials

$Fe^{3+} + 3e^- \rightarrow Fe$ $E^0 = -0{\cdot}036$ V

$Fe^{2+} + 2e^- \rightarrow Fe \quad E^0 = -0.440\ V$

The standard electrode potential E^0 for $Fe^{3+} + e^- \rightarrow Fe^{2+}$ is—

(A) $-0.476\ V$ (B) $-0.404\ V$

(C) $0.440\ V$ (D) $+0.772\ V$

45. The process requiring absorption of energy is—

(A) $F \rightarrow F^-$ (B) $Cl \rightarrow Cl^-$

(C) $O \rightarrow O^{2-}$ (D) $H \rightarrow H^-$

46. The ion that is isoelectronic with CO—

(A) CN^- (B) O_2^+

(C) O_2^- (D) N_2^+

47. The shape of water molecule is same as that of—

(A) C_2H_2 (B) CO_2

(C) NH_3 (D) Cl_2O

48. In a body centered cubic arrangement the ion A occupies the centre while ion B occupy the corners of a cube. The formula of the compound is—

(A) AB (B) A_2B

(C) AB_2 (D) AB_4

49. The radius of an ion in a body centred cube of edge, *a*, is—

(A) $\frac{a}{2}$ (B) $\frac{\sqrt{2}\,a}{4}$

(C) $\frac{\sqrt{3}\,a}{4}$ (D) a

50. What molar concentration of NH_3 provides a $[OH^-]$ of 1.5×10^{-3}

($K_b = 1.8 \times 10^{-5}$)

(A) 0·125

(B) $\{0.125 + 1.5 \times 10^{-3}\}$

(C) $\{0.125 - 1.5 \times 10^{-3}\}$

(D) 1.5×10^{-3}

ANSWERS

1. (A) 2. (D) 3. (B) 4. (D) 5. (C)
6. (D) 7. (B) 8. (D) 9. (C) 10. (D)
11. (C) 12. (C) 13. (A) 14. (A) 15. (C)
16. (C) 17. (C) 18. (A) 19. (A) 20. (A)
21. (B) 22. (C) 23. (B) 24. (D) 25. (B)
26. (C) 27. (B) 28. (B) 29. (D) 30. (A)
31. (A) 32. (A) 33. (C) 34. (C) 35. (B)
36. (B) 37. (D) 38. (A) 39. (D) 40. (C)
41. (B) 42. (A) 43. (B) 44. (D) 45. (C)
46. (A) 47. (D) 48. (A) 49. (C) 50. (B)

HINTS

1. Energy of subshells increases in the order

$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p$.....

$n = 1$ (first shell) $l = 0$ (*s* subshell)

$n = 2$ (second shell) $l = 1$ (*p* subshell)

$n = 3$ (third shell) $l = 2$ (*d* subshell)

$n = 4$ (fourth shell) $l = 3$ (*f* subshell)

Therefore,

(i) $n = 4$ $l = 1$ represents $4p$ subshell

(ii) $n = 4$ $l = 0$ represents $4s$ subshell

(iii) $n = 3$ $l = 2$ represents $3d$ subshell

(iv) $n = 3$ $l = 1$ represents $3p$ subshell

Thus, order of increasing energy (from lowest to highest) is

(iv) < (ii) < (iii) < (i)

2. $_{92}U^{235} + {}_0n^1 \longrightarrow {}_{54}Xe^{139} + {}_{38}Sr^{94} + {}_{30}n^1$

(Mass no R.H.S. = 236) (Mass no L.H.S. = 236)

Hence 3 neutrons are released.

3. Amount of heat required to raise the temperature of 1 mole of a substance through 1°C is called its molar heat capacity.

In the given system

Ice $\rightleftharpoons$ Water, ΔH = positive (Endothermic)

When heat is supplied the equilibrium is disturbed and forward process is favoured. Howsoever there is no change in temperature.

Thus amount of heat supplied to increase the temperature of this equilibrium is infinity.

4. The change in enthalpy at 25°C and 1 atm pressure when 1 mole of CO_2 is formed from its elements

$$C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}$$

is called standard molar enthalpy of formation of CO_2 which is also the standard molar enthalpy of combustion of carbon (graphite).

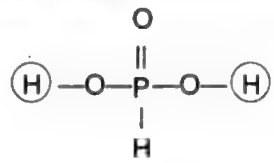
(Standard molar enthalpy of combustion of carbon is defined as the change in enthalpy at 25°C and 1 atm pressure when 1 mole of the carbon (graphite) is completely oxidised).

6. Normality of acid = Molarity × Basicity of acid

Basicity of phosphorus acid

$H_3PO_3 = 2$

It has two replaceable hydrogen atoms as evident from its structure formula



$\therefore$ Normality = 0.3×2

= 0·6

7. (i) NaCl solution does not undergo hydrolysis being the salt of strong acid and strong base. Resulting solution is neutral (pH = 7)

(ii) NH_4Cl is the salt of strong acid (HCl) and weak base (NH_4OH). The salt undergoes cation hydrolysis

$$NH_4^+ + H_2O \rightleftharpoons NH_4OH + H^+$$

The resulting solution is acidic (pH < 7)

(iii) NaCN is the salt of weak acid (HCN) and strong base (NaOH). It undergoes anion hydrolysis

$$CN^- + H_2O \rightleftharpoons HCN + OH^-$$

The resulting solution is basic (pH > 7)

(iv) HCl being a strong acid has low pH value. Increasing order of pH

$HCl < NH_4Cl < NaCl < NaCN$

8. $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Cr_2O_3 + 4H_2O + N_2$

9. $4AlF_3$ (from cryolite) $\rightleftharpoons 4Al^{3+} + 12F^-$

Anode (+)	**Cathode (–)**
$12F^- \rightarrow 6F_2 + 12e^-$	$4Al^{3+} + 12e^- \rightarrow 4Al$

$2Al_2O_3 + 6F_2 \rightarrow 4AlF_3 + 3O_2 \uparrow$

(alumina)

Molten mixture of Al_2O_3 and Na_3AlF_6 (Cryolite) is electrolysed for extraction of Al metal.

10. The chain contains double and triple bonds and the sum of the numbers turns out to be the same starting either of the side of carbon chain for double and triple bonded carbon atoms. According to IUPAC lower no. is given to double bonds carbon atom.

$CH_2=CH-CH_2-CH_2-C\equiv CH$

1 2 3 4 5 6

C_2 is sp^2 hybridized

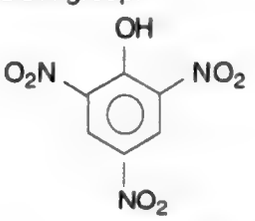
C_3 is sp^3 hybridized

Thus C_2-C_3 bond is of sp^2-sp^3 type

11. Be^{2+} is isoelectronic with Li^+, but former has a greater nuclear charge.

12. Hardness of water is due to the presence of bicarbonates and chlorides and sulphates of calcium and magnesium.

13. **Picric acid**—It is trinitrophenol and does not contain any —COOH group.



14. First I.P. of N > O since nitrogen has half filled orbitals which provides greater stability

N (at. no. = 7) $1s^2 2s^2 p_x^1 p_y^1 p_z^1$ (Half filled orbitals)

O (at. no. = 8) $1s^2 2s^2 p_x^2 p_y^1 p_z^1$

15. Molarity $= \frac{W}{m} \times \frac{1000}{V}$

W = Wt. of CH_3OH

m = mol. wt. of CH_3OH = 32

V = Volume of solution in ml = 150 ml

molarity = 2·0 M

$\therefore \quad 2 = \frac{W}{32} \times \frac{1000}{150}$

or, $\quad W = \frac{2 \times 32 \times 150}{1000}$

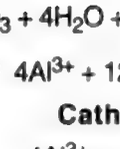
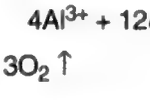
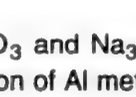
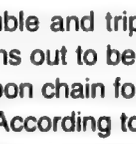
W = 9·6 g

16. **Markownikoff's rule :** Negative part of reagent is added to that double bonded carbon atom which has least no. of hydrogen atoms. *e.g.*

$CH_3-CH_2-CH=CH_2 + HBr \rightarrow$

$CH_3-CH_2-CHBr-CH_3$

17.

Species	Hybridization	Shape
NF_3 	sp^3	Pyramidal
NO_3^- 	sp^2	Trigonal planar
BF_3 	sp^2	Trigonal planar
H_3O^+ 	sp^3	Pyramidal

Isostructural pairs are

$[NF_3, H_3O^+]$ and $[NO_3^-, BF_3]$

18. Dissociation constant is given by Ostwald dilution formulae

$$K = \frac{\alpha^2 C}{(1-\alpha)}$$

α = Degree of dissociation

C = Concentration in moles/lit.

Here $\quad \alpha = 0{\cdot}001\% = \frac{0{\cdot}001}{100} = 10^{-5}$

C = 1·0 M

Since α is smell, $(1-\alpha) \approx 1$

$K = \alpha^2 C = (10^{-5})^2 \times 1$

$K = 10^{-10}$

19. Lower the reduction potential higher is the reducing power of metal

Metal	Reduction potential
X	0·52 V
Y	– 3·03 V
Z	– 1·18 V

Reducing power of the metals Y > Z > X

20. Energy of an electron revolving in nth orbit of hydrogen atoms.

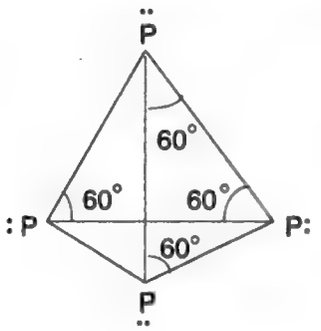
$$E_n = -\frac{2\pi^2 me^4}{n^2h^2} = -\frac{13{\cdot}6}{n^2} \text{ eV}$$

Hence $\quad E_1 = -13{\cdot}6$ eV $\quad (n=1)$

$$E_2 = -\frac{13{\cdot}6}{(2)^2} = -3{\cdot}4 \text{ eV} \quad (n=2)$$

$$E_3 = -\frac{13{\cdot}6}{(3)^2} = -1{\cdot}51 \text{ eV} \quad (n=3)$$

21. Structure of P_4 is tetrahedral as shown in fig. It contains



(1) 6 $p-p$ single bond

(2) P P P angle = 60°

(3) 4 Lone pairs of electrons

22. **Chromyl chloride test**

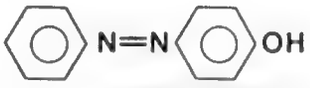
$$4NaCl + K_2Cr_2O_7 + 3H_2SO_4 \xrightarrow{warm} K_2SO_4 + 2Na_2SO_4 + 3H_2O + 2CrO_2Cl_2$$

Chromyl chloride (red vapours)

$$CrO_2Cl_2 + \underset{\text{(Solution)}}{4NaOH} \longrightarrow 2NaCl + \underset{\substack{\text{Sodium chromate}\\\text{(Yellow solution)}}}{Na_2CrO_4} + 2H_2O$$

23. Coupling reaction occurs.

Benzene diazonium chloride — Phenol



p-hydroxyazobenzene

24. $\pi V = ST$ (analogous to $PV = RT$)

$$\pi = \frac{1}{V}ST$$

Since $\frac{1}{V} = C$

$\begin{pmatrix} V = \text{Dilution in litres/mole} \\ C = \text{Concentration in moles/litre} \end{pmatrix}$

$\therefore \quad \pi = CST$

25. Empirical formula CH_2

Empirical formula wt. = 14

Mass of 1 mole = 42 g

$\therefore$ Molecular wt. = 42

$$n = \frac{42}{14} = 3$$

Molecular formula = $(CH_2)_3 = C_3H_6$

26. $\underset{\substack{2\text{ mol}\\(=78\times 2\\=156\text{ g})}}{2C_6H_{6(l)}} + \underset{\substack{15\text{ mol}\\(15\times 22{\cdot}4\text{ litre}\\=336\text{ litre at STP})}}{15O_{2(g)}} \longrightarrow \underset{12\text{ mol}}{12CO_{2(g)}} + \underset{6\text{ mol}}{6H_2O_{(g)}}$

$\therefore$ 156 g benzene requires

= 336 litre O_2 at STP

39 g benzene requires = $\frac{336}{156} \times 39$ litre O_2 at STP

= 84 litre

27. $Na + C + N + S \longrightarrow \underset{\text{Sod. thiocyanate}}{NaCNS}$

29. Dichlorodifluoro methane or freon (CCl_2F_2) is used in refrigeration.

30. Carbylamine reaction (isocyanide test)

$$\underset{\text{(Aniline)}}{C_6H_5NH_2} + \underset{\text{(Chloroform)}}{CHCl_3} + 3KOH(alc.) \xrightarrow{Warm} \underset{\substack{\text{(Phenyl}\\\text{isocyanide)}}}{C_6H_5NC} + 3KCl + 3H_2O$$

32. $\underset{\text{(X)}}{CaCO_3} \xrightarrow{\Delta} \underset{\text{(Residue)}}{CaO} + \underset{\text{(Colourless gas)}}{CO_2}$

$$CaO + H_2O \longrightarrow \underset{\text{(Y)}}{Ca(OH)_2}$$

$$\underset{\text{(Y)}}{Ca(OH)_2} + \underset{\text{(Excess)}}{2CO_2} \longrightarrow \underset{\text{(Z)}}{Ca(HCO_3)_2}$$

$$\underset{\text{(Z)}}{Ca(HCO_3)_2} \xrightarrow{heat} CaCO_3 + H_2O + CO_2$$

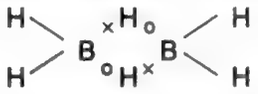
33. Smaller the size and greater the charge on cation higher is its hydration energy.

Hydration energy of Mg^{2+} ion is, therefore, greater than that of Na^+.

34. Moving from left to right in a period of periodic table the basic character of oxides decreases (or acidic character increases).

Al_2O_3 is most acidic among the given oxides.

35. Three centered bond is present in B_2H_6 (diborane)



Each boron atom is sp^3 hybridised. Three sp^3 hybridised orbitals contain one electron each whereas fourth sp^3 hybridised orbital is vacant. Overlapping of a vacant sp^3 hybridised orbital, one singly occupied sp^3 hybridised orbital of second B-atom and *s*-orbital of hydrogen atom result in the formation of 2 electrons 3 centered bond.

36. Solid CO_2 is called 'dry ice'.

37.

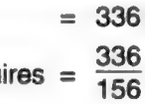
O_2	:	N_2	
1	:	4	(mass ratio)
$\frac{1}{32}$	:	$\frac{4}{28}$	(mole ratio)
= 7	:	32	

Ratio of molecules is the same as ratio of moles

$O_2 : N_2 = 7 : 32$

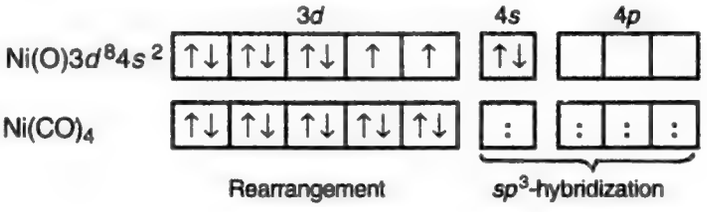
38. NF_5 does not exist as in nitrogen no *d*-orbital is present and thus five half filled orbitals are NOT available.

39.

Molecule	Hybridization	Shape
H_2S 	sp^3	V-shaped
SO_2 	sp^2	V-shaped
H_2O 	sp^3	V-shaped
CS_2 (S=C=S)	sp	Linear

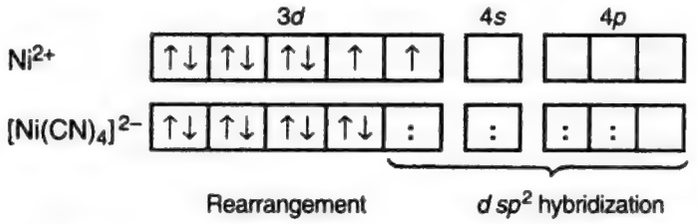
Due to symmetrical structure CS_2 does not possess dipole moment.

40. (i) $Ni(CO)_4$—Nickel atom undergoes sp^3 hybridization, hence it is tetrahedral in shape



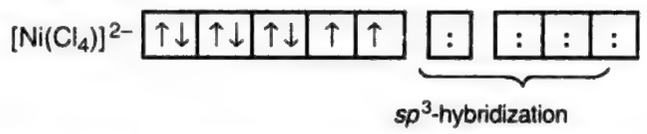
There is no unpaired electron, hence it is diamagnetic.

(ii) $[Ni(CN)_4]^{2-}$ – Ni^{2+} ion undergoes dsp^2 hybridization. Hence square planar in shape



There is no unpaired electron, hence this is also diamagnetic.

(iii) $[Ni(Cl_4)]^{2-}$ – Ni^{2+} ion is sp^3 hybridized



Two orbitals are singly occupied (*i.e.* having unpaired electrons). Hence it is paramagnetic.

Note—Strong field ligands like CN^- and CO have very strong electron donating tendency, therefore, electrons of central metal ion pair up against Hund's rule.

41. Orbital angular momentum of an electron

$$L = \sqrt{l(l+1)}\left(\frac{h}{2\pi}\right)$$

For 2*s* orbital

$$l = 0$$

$$\therefore \quad L = \sqrt{0\,(0+1)}\left(\frac{h}{2\pi}\right) = 0$$

42. $$-\frac{dN}{dt} = \lambda N$$

$$-\frac{dN}{dt} = \text{activity}$$

(*i.e.* no. of nuclei disintegrating per sec)

λ = decay constant

N = number of nuclei present

Given $\lambda = 1{\cdot}37 \times 10^{-11}\ sec^{-1}$

$$-\frac{dN}{dt} = 1{\cdot}5 \times 3{\cdot}7 \times 10^7$$

$$\left(\because 1 \text{ curie} = 3{\cdot}7 \times 10^{10} \text{ d.p.s.}\right)$$

$$N = -\frac{dN}{dt} \cdot \frac{1}{\lambda}$$

$$= \frac{1{\cdot}5 \times 3{\cdot}7 \times 10^7}{1{\cdot}37 \times 10^{-11}} \text{ atoms}$$

$$= 4{\cdot}05 \times 10^{18} \text{ atoms}$$

43. **Reducing agent**—O.N. of key atom (s) is increased

$$Cr_2O_7^{2-} + 14H^+ + 3Ni \longrightarrow 2Cr^{3+} + 7H_2O + 3Ni^{2+}$$

3 (O) → 6*e*; (+ 2)3

O.N. of Ni is increased (Ni is reducing agent)

44. Electrode potential is NOT an additive property. Howsoever, free energy change $-\Delta G = n\,FE$ is additive in nature.

$$\therefore \quad E_1 + E_2 \neq E_3 \qquad \ldots(i)$$

$$-\Delta G_1 + (-\Delta G_2) = -\Delta G_3 \qquad \ldots(ii)$$

From eqn. (ii) it can be derived

$$n_1FE_1 + n_2FE_2 = n_3FE_3$$

or, $$\boxed{n_1E_1 + n_2E_2 = n_3F_3}$$

			E^0	nE^0
(1)	$Fe^{3+} + 3e^-$	$\rightarrow$ Fe	– 0·036 V	– 0·108
(2)	$Fe^{2+} + 2e^-$	$\rightarrow$ Fe	– 0·440 V	– 0·880
(1) – (2)	$Fe^{3+} + e^-$	$\rightarrow$ Fe^{2+}	—	+ 0·772

$$\because \quad nE^0 = +0{\cdot}772$$

$$n = 1$$

(For the reaction $Fe^{3+} + e \rightarrow Fe^{2+}$ as, only one electron is involved)

$$\therefore \quad E^0 = +\frac{0{\cdot}772}{1} = 0{\cdot}772\ V$$

45. Energy is released when first electron is added to an isolated gaseous atom. Howsoever, when second electron is added energy is required to overcome the electronic repulsion

$$O + e^- \longrightarrow O^- \text{ (exothermic)}$$

$$O^- + e^- \longrightarrow O^{2-} \text{ (endothermic)}$$

Net reaction

$$O + 2e^- \longrightarrow O^{2-} \text{ (endothermic)}$$

46.

Species	No. of electrons
$\boxed{CN^-}$	$\boxed{6 + 7 + 1 = 14}$
O_2^+	8 + 8 – 1 = 15
O_2^-	8 + 8 + 1 = 17
N_2^+	7 + 7 – 1 = 13
$\boxed{CO}$	$\boxed{6 + 8 = 14}$

$\therefore$ CN^- is isoelectronic with CO.

47.

Molecule	Hybridization	Shape
C_2H_2 (H—C≡C—H)	*sp*	Linear
CO_2 (O=C=O)	*sp*	Linear
NH_3 (H—N(H)—H)	sp^3	Pyramidal
Cl_2O (Cl—O—Cl)	sp^3	V-shaped
H_2O (H—O—H)	sp^3	V-shaped

48. **In a body centered cubic lattice ion A occupied centre**

$\therefore$ No. of ion A associated with each unit cell

= 1

Ion B occupied the corners of the cube

No. of ion B associated with each unit cell

$$= 8 \times \frac{1}{8} = 1$$

$\therefore$ Formula of crystal is AB.

(Continued on Page 79)

Best Fifteen Questions

CHEMISTRY

1. X ml of H_2 gas effuses through a hole in a container in 5 second. The time taken for the effusion of the same volume of the gas specified below under identical conditions is—
   (A) 10 sec : He
   (B) 20 sec : O_2
   (C) 25 sec : CO
   (D) 55 sec : CO_2

2. A metal oxide has the formula Z_2O_3. It can be reduced by hydrogen to give free metal and water. 0·1596g of the metal oxide requires 6 mg of hydrogen for complete reduction. The atomic wt. of the metal is—
   (A) 27·90 (B) 159·60
   (C) 79·80 (D) 55·80

3. The wave number of the first line in Balmer series of hydrogen is 15200 cm^{-1}. The wave number of the first line in the Balmer series of Li^{2+} is—
   (A) 15200 cm^{-1}
   (B) 60800 cm^{-1}
   (C) 76000 cm^{-1}
   (D) 136800 cm^{-1}

4. Pick out the isoelectronic structures from the following :
   (I) CH_3^+ (II) H_3O^+
   (III) NH_3 (IV) CH_3^-
   (A) (I) and (II)
   (B) (I) and (IV)
   (C) (I) and (III)
   (D) (II), (III) and (IV)

5. The oxidation number of sulphur in $Na_2S_4O_6$ is—
   (A) 2·5
   (B) 2 and 3 (two S have + 2 and other two have + 3)
   (C) 2 and 4 (three S have + 2 and one S has + 4)
   (D) 5 and 0 (two S have + 5 and the other two have 0)

6. The H^+ ion concentration in 0·001 M acetic acid of $K_a = 1·8 \times 10^{-5}$ is $1·34 \times 10^{-4}$ g ions/litre. What will be the H^+ ion concentration if 0·164 g of sodium acetate is added to a litre of 0·001 M CH_3COOH ?
   (A) 9×10^{-6} M
   (B) 18×10^{-6} M
   (C) $4·5 \times 10^{-6}$ M
   (D) 5×10^{-6} M

7. Assuming complete dissociation the following will have pH equal to 12—
   (A) 50 ml 0·005 M KOH
   (B) 100 ml 0·01 M KOH
   (C) 200 ml 0·02 M NaOH
   (D) 400 ml 0·01 M $Ca(OH)_2$

8. Cyclohexanol is dehydrated to cyclohexene on heating with conc. H_2SO_4. If the yield of this reaction is 75%, how much cyclohexene will be obtained from 100 g of cyclohexanol ?
   (A) 61·5 g (B) 75·0 g
   (C) 20·0 g (D) 41·0 g

9. At room temperature sodium crystallises in a body centered cubic lattice with $a = 4·24$ Å. The theoretical density of sodium.
   (At. wt. of Na = 23)
   (A) 1·002 g cm^{-3}
   (B) 2·002 g cm^{-3}
   (C) 3·002 g cm^{-3}
   (D) None of the above

10. Which statement about bond energy could be correct ?
    (A) The bond energy is the energy required to break a bond between two atoms
    (B) The bond energy is the energy released when two atoms join together to form a bond
    (C) The bond energy is the energy required to break one mole of the bonds
    (D) Single covalent bonds all have the same bond energy

11. A good test to distinguish between oxalic, malonic and succinic acids would be—
    (A) To heat them and examine the products
    (B) Their reaction with $CaCl_2$
    (C) Their reaction with acidified $KMnO_4$
    (D) Their reaction with NH_3

12. Chlorination of toluene in presence of light and heat followed by treatment with aqueous NaOH gives—
    (A) *o*-cresol
    (B) *p*-cresol
    (C) 2 : 4 dihydroxy toluene
    (D) Benzoic acid

13. All common *m*-directing groups ... the benzene ring towards electrophilic substitution reactions—
    (A) Deactivates
    (B) Activates
    (C) Both
    (D) None of the above

14. The following reaction is known by the name of
    $CH_3COCl + H_2 \xrightarrow[Pd/BaSO_4]{[H]} CH_3CHO + HCl$
    (A) Stephen's reduction
    (B) Rosenmund's reaction
    (C) Cannizzaro reaction
    (D) None of the above

15. At the isoelectric point for amino acid the species present are—
    (A) $R—\underset{\displaystyle NH_2}{\underset{|}{CH}}—COOH$
    (B) $R—\underset{\displaystyle NH_3^+}{\underset{|}{CH}}—COOH$
    (C) $R—\underset{\displaystyle NH_2}{\underset{|}{CH}}—COO^-$
    (D) $R—\underset{\displaystyle NH_3^+}{\underset{|}{CH}}—COO^-$

ANSWERS WITH HINTS

1. (B) 2. (D) 3. (D) 4. (D) 5. (D) 6. (A) 7. (B)
8. (A) 9. (A) 10. (C) 11. (A) 12. (D) 13. (A) 14. (B)
15. (D)

1. $$\frac{\gamma_1}{\gamma_2} = \frac{V_1/t_1}{V_2/t_2} = \sqrt{\frac{M_2}{M_1}} \quad \ldots (I)$$

Since same volume of gases were effused

$$\frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}} \quad \ldots (II)$$

t_1 = 5 sec M_1 = 2 (molecular wt. of H_2)

$$\therefore \quad \frac{t_2}{5} = \sqrt{\frac{M}{2}} \quad \ldots (III)$$

Eqn. (III) satisfies when t_2 = 20 sec and M_2 = 32 (mol. wt. of O_2)

2. Formula of metal oxide = Z_2O_3

$\therefore$ Valency of metal = 3

From Law of equivalent weights

$$\frac{\text{Wt. of metal oxide}}{\text{Equivalent wt. of metal oxide}} = \frac{\text{Wt. of } H_2}{\text{Eq. wt. of } H_2}$$

$$\frac{0{\cdot}1596}{E+8} = \frac{6\times10^{-3}}{1}$$

(E = Equivalent wt. of metal
Equivalent wt. of oxygen = 8,
Equivalent weight of hydrogen = 1)

$$0{\cdot}1596 = 6\times10^{-3}\,E + 0{\cdot}048$$

$$E = \frac{0{\cdot}1116}{0{\cdot}006} = 18{\cdot}6$$

Atomic wt. = equivalent wt × valency

$\therefore$ Atomic wt. = $18{\cdot}6\times3 = 55{\cdot}80$

3. For first line in Balmer series the electron must jump from 3rd to 2nd orbit.

$$\bar{\upsilon} = \frac{1}{\lambda} = R_Z{}^2\left(\frac{1}{n'^2}-\frac{1}{n^2}\right)$$

where $n > n'$

For hydrogen atom (Z = 1)

$$\bar{\upsilon} = \frac{1}{\lambda} = R\left(\frac{1}{3^2}-\frac{1}{2^2}\right) = 15200\ cm^{-1}$$

For Li^{2+} ion (Z = 3)

$$\bar{\upsilon} = \frac{1}{\lambda} = R(3)^2\left(\frac{1}{3^2}-\frac{1}{2^2}\right)$$

$$= 9\times15200\ cm^{-1} = 136800\ cm^{-1}$$

4.

Species	No. of valence electrons
CH_3^+	$6+3(1)-1 = 8$
H_3O^+	$3(1)+8-1 = 10$
NH_3	$7+3(1) = 10$
CH_3^-	$6+3(1)+1 = 10$

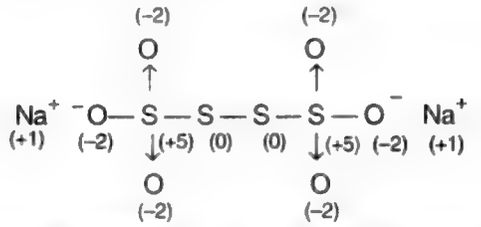
Since H_3O^+, NH_3 and CH_3^- are isoelectronic, they have similar structures.

5. Rules for calculating O.N.

(i) Electrons pair shared between identical atoms are divided equally to calculate charge on an atom.

(ii) Electrons pair shared between two dissimilar atoms is counted with more electronegative atom.

Structure of $Na_2S_4O_6$ is as follows :



In brackett oxidation no. of each atom is shown.

6. When sodium acetate is added to acetic acid dissociation of weak acid (CH_3COOH) is almost suppressed. It is present almost in unionised form.

Sodium acetate being strong electrolyte ionises almost completely. Consequently CH_3COO^- ions concentration is equal to the concentration of salt

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

$$K_a = \frac{[CH_3COO^-]\,[H^+]}{[CH_3COOH]}$$

$$\therefore \quad [H^+] = K_a\frac{[CH_3COOH]}{[CH_3COO^-]}$$

Given $[CH_3COOH] = 0{\cdot}001$ M

$$[CH_3COONa] = \frac{0{\cdot}164\ (g/lit.)}{82\ (mol.\ wt.)} = 0{\cdot}002\ M$$

$\therefore$ $[CH_3COO^-] = 0{\cdot}002$ M

Hence $$[H^+] = \frac{1{\cdot}8\times10^{-5}\times0{\cdot}001}{0{\cdot}002}$$

$$= 9\times10^{-6}\ M.$$

7. pH = 12

$[H^+] = 10^{-12}$ M (by definition of pH)

$\therefore$ $[OH^-] = 10^{-2}$ M ($\because$ $[H^+]\,[OH^-] = 10^{-14}$)

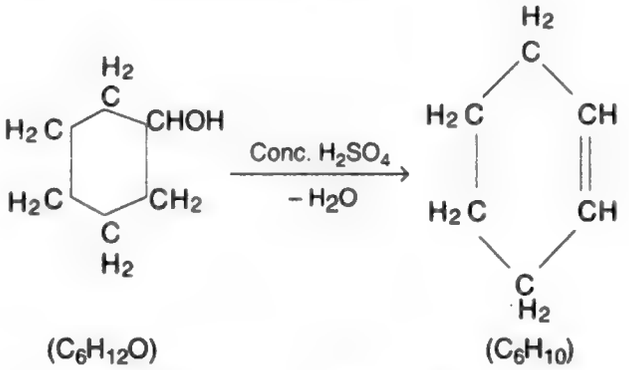
(A) 0·005 M KOH $[OH^-] = 5\times10^{-3}$ M

(B) 0·01 M KOH $[OH^-] = 1\times10^{-2}$ M

(C) 0·02 M NaOH $[OH^-] = 2\times10^{-2}$ M

(D) 0·01 M $Ca(OH)_2$ $[OH^-] = 1\times10^{-2}\times2$M

8.



$(C_6H_{12}O)$ (C_6H_{10})

100 g cyclohexanol = $\frac{100}{100}$ = 1 mol

1 mol cyclohexanol yields 0·75 mol cyclohexene (yield = 75%)

0·75 mol cyclohexene = $0{\cdot}75\times82 = 61{\cdot}5$ g

9. Theoretical density of a cubic crystal can be calculated from the equation.

$$\rho = \frac{n\,M}{NV}$$

n = number of atoms in the unit cell

N = Avogadro number

M = Molar mass

V = Volume of unit cell

In body centered unit cell eight atoms are at eight corners and one atom is at the centre of the cube.

$$n = \frac{1}{8} \times 8 \text{ (corner atoms)} + 1 \text{ (central atom)} = 2$$

M = 23 g (for sodium)

$$V = a^3 = (4{\cdot}24 \times 10^{-8})^3 \text{ cm}^3$$

$$V = 7{\cdot}62 \times 10^{-23} \text{ cm}^3$$

$$\therefore \quad \rho = \frac{2 \times 23}{6{\cdot}02 \times 10^{23} \times 7{\cdot}62 \times 10^{-23}} \text{ g/cm}^3$$

$$\rho = 1{\cdot}002 \text{ g cm}^{-3}$$

10. Bond energy is defined as the change in enthalpy (ΔH) when one mole of bonds between two atoms are broken down to form constituent gaseous atoms.

Hence statement **(C) is true**.

11. $$\begin{matrix}COOH\\|\\COOH\end{matrix} \xrightarrow{\Delta} CO + CO_2 + H_2O$$

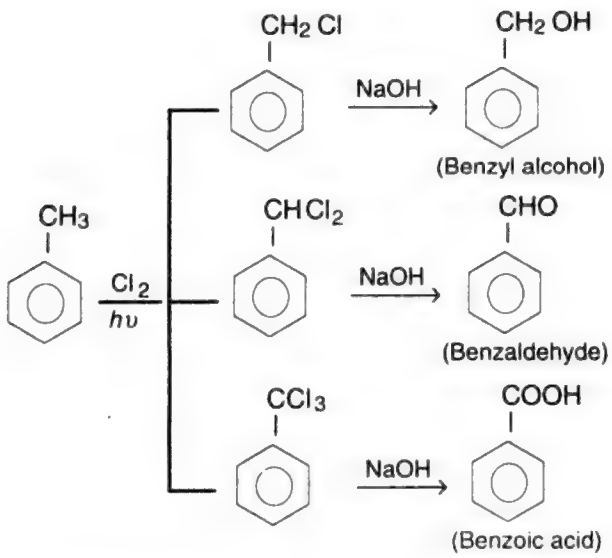
$$CH_2\begin{matrix}COOH\\COOH\end{matrix} \xrightarrow{\Delta} CH_3COOH + CO_2$$

$$\begin{matrix}CH_2COOH\\|\\CH_2COOH\end{matrix} \xrightarrow{\Delta} \begin{matrix}CH_2CO\\|\\CH_2CO\end{matrix}\!\!>O + H_2O$$

Oxalic acid forms both CO_2 and H_2O, while malonic acid gives CO_2 and succinic acid yields H_2O.

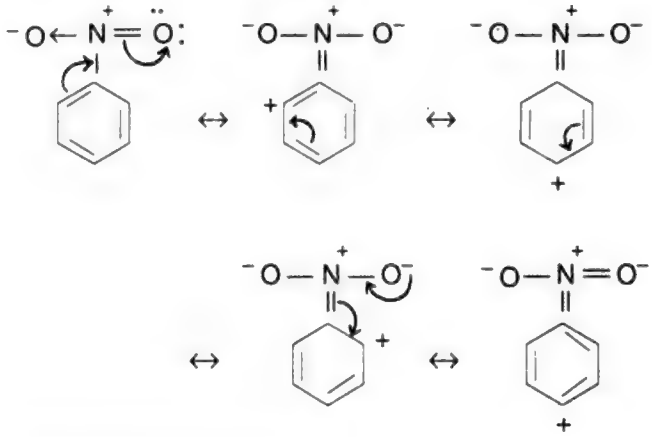
Note—Two —COOH on one carbon atom on heating lose CO_2. Two —COOH on adjacent carbon atoms lose H_2O.

12.



13. The presence of *m*-directing groups in benzene nucleus simply decreases electron density at *o*- and *p*- whereas no change in electron density is noticed at *m*-position.

In nitro benzene (– NO_2 is *m*–directing)



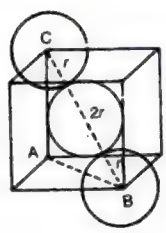
(Resonating structures)

14. Rosenmund's reaction involves reduction of acid chlorides to aldehydes by the action of H_2 in presence of Pd /$BaSO_4$.

$BaSO_4$ acts as poison for catalyst Pd and prevents further reduction of aldehyde to alcohol. ●●●

(Continued from Page 76)

49. Edge length of cube = a



$$AC = a$$

$$AB = \sqrt{a^2 + a^2} = \sqrt{2}a$$

$$BC^2 = AB^2 + AC^2$$

$$BC^2 = 2a^2 + a^2 = 3a^2$$

or, $$BC = \sqrt{3}a$$

Radius of an ion $$r = \frac{\sqrt{3}a}{4} \quad (\because BC = 4r)$$

50. $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

CM $\quad 1{\cdot}5 \times 10^{-3}$ M $\quad 1{\cdot}5 \times 10^{-3}$ M (at $\rightleftharpoons$)

$$\because \quad K_b = \frac{[NH_4^+]\,[OH^-]}{[NH_3]}$$

$$\therefore \quad 1{\cdot}8 \times 10^{-5} = \frac{(1{\cdot}5 \times 10^{-3})\,(1{\cdot}5 \times 10^{-3})}{C}$$

$$C = \frac{(1{\cdot}5)^2 \times 10^{-6}}{1{\cdot}8 \times 10^{-5}}$$

$$= 1{\cdot}25 \times 10^{-1} = 0{\cdot}125 \text{ M}$$

Hence initial concentration of NH_3

$$= \{0{\cdot}125 + 1{\cdot}5 \times 10^{-3} \text{ M}\}$$

●●●

Annelida—*Pheretima posthuma* (Earthworm)

The common Indian earthworm, *Pheretima posthuma,* serves well to illustrate the principal characteristics of the annelids. Earthworms are found almost all over the world in the temperate and tropical regions whereever there is plenty of moisture in the ground. They prefer loamy or partly sandy soil rich in humus. Dr. K.N. Bahl thoroughly worked out the anatomy of *Pheretima posthuma.* An earthworm is usually studied as a type of Annelida because it is easily available almost everywhere.

Habits and Habitat

Pheretima posthuma is a terrestrial earthworm living in burrows made in moist soil (earth). It prefers to live in burrow during day and comes out at night in damp cloudy weather. It is thus nocturnal in habit.

Earthworm makes its burrow partly by boring with its pointed anterier end and partly by sucking and swallowing the soil. It feeds on dead organic matter present in soil. Food and soil are ingested together and the latter, along with undigested food is finally egested in the form of worm castings. Earthworms are hermaphrodite, but they undergo copulation for exchange of their spermatozoa. Fertilization and development occur inside a cocoon. Earthworm possess great power of regeneration.

External Morphology

Shape and size—Earthworm is bisymmetrical animal. Its body is cylindrically elongated, pointed in front, blunt behind and thickest a little behind the anterior end. It is well-adapted for burrowing. A mature worm measures about 150 mm in length and 3 to 5 mm in width.

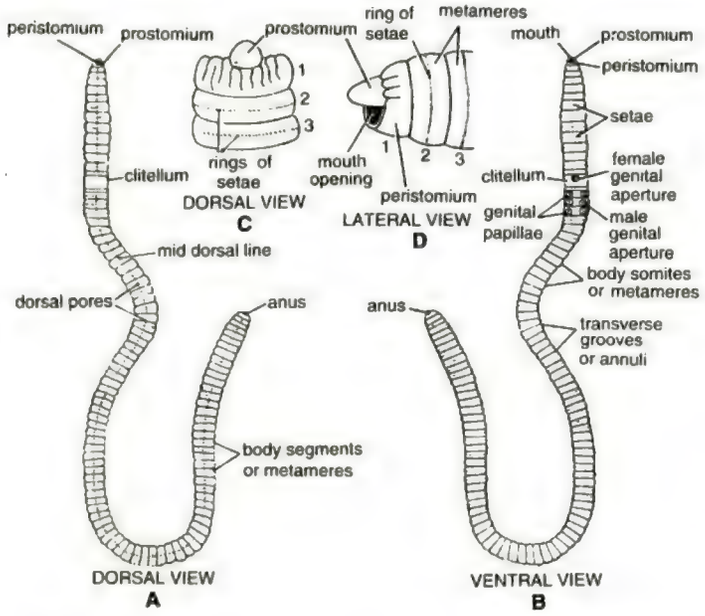


Fig. : *Pheretima posthuma.* A—Entire worm in dorsal view. B—Entire worm in ventral view. C—Anterior end in dorsal view. D—Anterior end in lateral view.

Colouration—Earthworm is of a glistening deep-brown in colour. Dorsal surface is darker than the ventral surface and carries a dark coloured median line due to dorsal blood vessel which is seen through the integument. Brown colour of worm is due to the pigment **porphyrin** present in body wall and it protects the body against bright and ultraviolet radiation of sunlight.

Segmentation—Soft and naked body of earthworm is divided into 100 to 120 similar segments, called **metameres** or **somites**. The body segmentation in earthworm is called **'metameric segmentation (metamerism)'**, due to the presence of similar body segments along the longitudinal axis of the body. The segments are without parapodia, and segments are separated from each other by distinct ring-like grooves. External segmentation corresponds with the internal segmentation of body.

Head—The earthworm has no distinct head and no conspicuous sense organs on the head. The first segment at the anterior end of the body is called **buccal segment** or **peristomium** bearing the terminal crescentic mouth. It is prolonged anteriorly into a fleshylobe, the **prostomium** which overhangs the mouth.

Hind end—The last segment of the body is known as the anal segment and carries the terminal anus.

Clitellum—In mature worms, a conspicuous external feature is a girdle-like thick band of glandular tissue, the **clitellum** or **cingulum**, which completely surrounds segments 14 to 16. Due to its presence, the body is distinguished into pre-clitellar, clitellar, and post-clitellar regions. The segments forming clitellum are not distinct. Clitellum is glandular organ which secretes **mucus, albumen** and an egg-case or **cocoon** for eggs.

Setae—About the middle of each segment there is a ring of tiny curved bristles, called **setae** or **chaetae**, formed of a horny nitrogenous organic substance, known as **chitin**. About 80 to 120 setae are present on each segment. Each seta is embeded in a small pit in body wall, called **setigerous** or **setal sac**. It is formed by a single **formative cell** present in the basal part of sac. It has a faint yellow colour and is shaped like an elongated 'S' with a swollen middle part, called **nodulus.** About one-third of its length projects above the surface of skin in a contracted segment. The setae are operated by special muscles and help the worm in locomotion by securing a firm grasp of the soil on surface of the ground. They can be moved in any direction and extended or withdrawn by the action of these muscles. Worn out setae fall out of the bodywall and get renewed repeatedly. There are no setae in the first and the last segments and also in the clitellum of a mature worm. The arrangement of numerous setae in a ring in each segment is known as **perichaetine arrangement,** as found in *Pheretima.*

External apertures

The various apertures present on the body of earthworm are as follows :

1. **Mouth**—The mouth is a crescentic aperture situated at the anterior end. It is surrounded by the first segment of the body (*i.e.*, peristomium).

2. **Anus**—The last segment of the body or the anal segment bears the terminal anus, which is a vertical slit-like aperture.

3. **Dorsal pores**—Minute openings, the dorsal pores, lie along the mid-dorsal line, one pore in each inter-segmental groove behind the 12th segment, except the last. By means of these pores the coelom communicates with the exterior. When the worm is disturbed, coelomic fluid may be ejected through these pores for defense, to increase the surface moisture or to moisten and lubricate the walls of the burrow.

4. **Nephridiopores**—A large number of very minute **nephridiopores** or the openings of the integumentary nephridia are scattered all over the body except the first two segments.

5. **Spermathecal pores**—The spermathecae open to the exterior through four pairs of small elliptical apertures, the **spermathecal pores**, situated ventro-laterally in the inter-segmental grooves 5/6, 6/7, 7/8 and 8/9 segments. Through these apertures spermatozoa are received from other worm during copulation.

6. **Female genital pore**—The oviducal or female genital pore is a single median aperture opening on the ventral surface of the clitellum on 14th segment, in a saucer-shaped depression.

7. **Male genital pore**—A pair of crescentic male genital pore, or the opening of the common prostatic and spermatic ducts, lie one on either side on the ventral surface of the 18th body segment.

8. **Genital papillae**—There are two pairs of conspicuous rounded elevations, the copulatory genital papillae, one pair on the ventral surface of each of the 17th and 19th body segments and in line with the male genital pores. Each papilla bears no aperture but a shallow cup-like depression at the top. During copulation, the genital papillae function as suckers.

Body wall

Body wall of earthworm comprises a thin cuticle, an epidermis, a well-developed musculature and a coelomic epithelium or parietal peritoneum.

Cuticle—The body wall is covered externally by a thin elastic cuticle. It is non-cellular and finely striated, irridescent, double-layered, and is secreted by underlying epidermis. It consists of collagenous protein and a polysaccharide along with a little quantity of gelatin. It bears many perforations, through which open the epidermal mucous glands. It protects the body from physical and chemical injuries.

Epidermis—It is single-layered and lying just beneath the cuticle. Cells of epidermis are of various types, performing different functions. **Supporting cells**, forming bulk of epidermis, are of columnar type. **Gland cells** include numerous **mucous cells** and a few **albumen cells** packed with secretory granules. **Basal cells**, which are small and rounded or conical, lie in spaces between inner ends of supporting cells and gland cells. **Receptor cells** occur in groups with their outer ends giving out fine hair-like processes. Epidermis rests on a thin basement membrane.

Muscles—Musculature lies below epidermis. It consists of an outer thin layer of circular muscle fibres running around the body, and an inner thick layer of longitudinal muscle fibres running along the length of body. Longitudinal muscle fibres lie in parallel bundles, separated by connective tissue and strengthened by collagen fibres. The muscle fibres are unstriped, long and spindle-shaped. When the circular muscle fibres contract, the diameter of the body is narrowed and the worm elongates. When the longitudinal muscle fibres contract, the diameter of the body becomes greater and the worm shortens. The two kinds of muscle fibres are antagonistic, because the contraction of one goes with the relaxation of the other.

Setal musculature—Two additional types of muscle also occur inserted at the base of each setal sac bearing a seta. These are a pair of protractor muscles passing outwards to join the circular muscle layer, and a single retractor muscle, passing inwards to join another thin sheet of circular muscles forming a ring below the longitudinal muscles. All the muscle fibres are unstriped.

Coelomic epithelium

The innermost layer of the body-wall is the somatic peritoneum or the parietal layer of coelomic epithelium, which also forms the outer lining of the body cavity. It consists of a single layer of flat or pavement cells which are recognizable by their nuclei only.

Functions of body wall

1. Maintains body form due to its elasticity.

2. Protects against mechanical injuries.

3. The mucus secreted by the epidermal glands keeps the surface slimy, clean and free from harmful organisms, and also helps in plastering the internal walls of the burrows.

4. The albumen serves as food for the developing embryos in the cocoons.

5. Sensory epidermal cells serve for reception of external stimuli.

6. The muscles help in movements.

7. Lodges setae which help in locomotion.

8. Body wall is moist, thin, highly vascular and permeable to gases. Thus it serves as respiratory organ.

9. The parietal layer of coelomic epithelium secretes coelomic fluid.

Coelom

Body cavity of earthworm is a true coelom which lies between body wall and alimentary canal. It is lined by coelomic epithelium derived from mesoderm. It communicates with the exterior through reproductive, nephridial and dorsal pores.

Septa—Coelom is divided into a series of coelomic chambers by transverse intersegmental septa. Each septum consists of a thin layer of interlacing muscle fibres, covered on both surfaces by coelomic epithelium. The septa are perforated by numerous apertures, through which communication is set up between adjacent coelomic chambers. The septa are absent in the first four segments. The first septum, lying between segments 4 and 5, is thin and membranous. The next five septa between segments 5/6, 6/7, 7/8, 8/9 and 10/11 are thick, muscular and cone like. The septa 11/12, 12/13 and 13/14 are thin and without perforations.

Coelomic fluid—Coelom is filled with an alkaline, colourless or milky coelomic fluid containing water, salts, some proteins and at least four types of coelomic corpuscles as follows—

1. **Phagocytes**—Largest and more numerous are the nucleated amoeboid corpuscles or phagocytes.

2. **Mucocytes**—These are elongate cells, each having a broad, fan-like process, attached to a narrow nucleated body.

3. **Circular cells**—About 10 per cent of coelomic corpuscles are rounded, nucleated and blood corpuscle-like cells possessing clear protoplasm and characteristic markings on surface.

4. **Chloragogen cells**—Also known as yellow cells, these are star-shaped, small-sized cells. They are supposed to be excretory in function removing excretory products from coelomic fluid.

Functions of Coelomic fluid

1. Helps in locomotion by turgescence.

2. Its circulation from one chamber to another helps in distribution of digested food.

3. Coelomic fluid exceeding through dorsal pores, keeps the body surface moist, thus helping in respiration.

4. It destroys harmful bacteria and other parasites of soil.

5. Forms a protective, shock-proof covering around internal organs of body.

6. Its chloragogen cells help in removing excretory products out of body.

7. It causes luminescence in some earthworms.

Locomotion

Movement in earthworm involves the musculature of body wall and setae. According to the studies of Gray and Lissman (1938), the worm's body undergoes extension, anchoring and contraction during the course of its progression. A wave of contraction, affecting circular muscles, begins at the anterior end and travels posteriorly. This causes the body to become thinner and longer. This is followed by another wave of contraction affecting longitudinal muscles causing thickening and shortening of body. This is again followed by the wave of thinning and the process is repeated alternately. Each wave of circular contraction causes the segments affected to move forward. But the segments in a state of longitudinal contraction do not move as they are anchored to the ground by the protruded setae. Setae always protrude during longitudinal contraction and retract during circular contraction. When the direction of waves is reversed, the worm crawls backwards.

During locomotion, coelomic fluid serves as a kind of **hydraulic skeleton**. When compressed due to contraction of circular muscles, it provides stiffness to body and aids in relaxation of longitudinal muscles.

Digestive system

The digestive system includes the alimentary canal and the associated digestive glands.

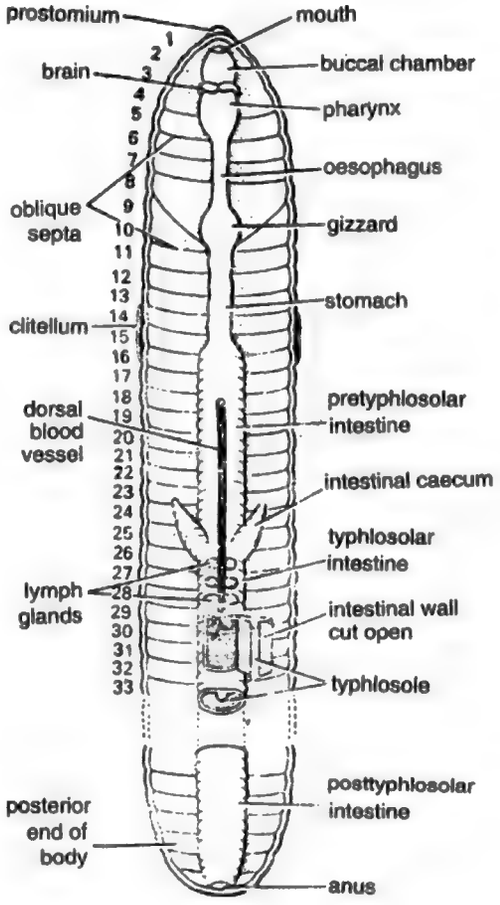


Fig. : *Pheretima*. Dissection of alimentary canal.

Alimentary canal—Alimentary canal is a complete and straight tube running along the entire length of body. Mouth and anus constitute its anterior and posterior openings respectively. It is functionally regionated into various parts which are buccal chamber, pharynx, oesophagus, gizzard, stomach and intestine.

Buccal chamber—Crescentic mouth, situated ventral to prostomium at the anterior end of peristomium, leads into a short and narrow protrusible buccal chamber, extending upto middle of third segment. Its lining epithelium is thrown into longitudinal folds.

Pharynx—Buccal chamber leads into a spacious pear-shaped muscular pharynx, which extends up to the fourth segment. Its anterior end is marked by the nerve ring placed in a transverse groove between it and buccal chamber. Its cavity is somewhat dorso-ventrally compressed due to the presence of large glandular pharyngeal mass producing a salivary secretion. Lateral walls of pharynx are pushed inside, thus divide the pharyngeal

cavity into a dorsal salivary chamber and a ventral conducting chamber. Salivary secretions contain mucus and proteolytic enzymes which are poured into the salivary chamber.

Oesophagus—Behind pharynx lies the oesophagus or gullet. It is a short, narrow, thin-walled tube. It extends up to the seventh segment.

Gizzard—Oesophagus is modified into a prominent, oval, hard and thick-walled muscular organ, the gizzard, lying in ninth segment. Its muscular wall consists of circular muscle fibres. It is internally lined by a tough cuticle.

Stomach—Gizzard is followed by a short narrow tube, the stomach, which extends from segments 9 to 14, with a sphincter at each end. Its walls are highly vascular and glandular and thrown into internal transverse folds.

Intestine—Region next to stomach is the intestine, which is a long, wide and thin-walled tube extending from 15th segment to the last. Its internal lining is ciliated, folded, vascular and glandular. Intestine is divisible into three parts :

1. **Pre-typhlosolar region**—The anterior part of intestine lying between segments 15 to 26 is known as pre-typhlosolar region. From 26th segment are given out externally a pair of forwardly–directed lateral conical outgrowths, the **intestinal caeca.** These are richly vascular and internally thrown into villi-like processes.

2. **Typhlosolar region**—This region lies between 27th upto 23–25 segments infront of anus. This is characterized by the presence of a highly glandular and vascular longitudinal ridge. This is called the **typhlosole.**

3. **Post-typhlosolar region**—The last part, also known as rectum, and is of 23–25 segments. It opens outside through the terminal anus.

Food and feeding mechanism

Earthworm feeds on dead organic matter, particularly vegetation along with soil. It ingests food by the pumping action of its pharynx. For feeding, it presses its mouth against soil and the contractile sucking action of pharyngeal wall draws fragments of soil into buccal chamber.

Physiology of digestion

Ingested food is pressed to move posteriorly. No digestion takes place inside buccal chamber. While passing through the ventral conducting chamber of pharynx, it meets salivary secretion. It contains mucin, which lubricates the food and an enzyme **protease** which digests the proteins. Food then passes into gizzard. The gizzard, acting as a grinding machine, pulverises the food mass. This is facilitated by the contractile movements of its muscular wall which cause the food to roll about. In stomach, a chalky secretion of calciferous glands located in stomach wall, neutralizes the humic acids present in soil. Intestine is the principal site of digestion. Intestinal wall consists of glandular cells which secrete digestive juice containing pepsin, trypsin, amylase, lipase and cellulase. Digestion is extracellular in earthworm, as in higher animals. Intestine also functions for absorbing the digested nutrients. After being absorbed by the absorptive cells of intestinal epithelium, nutrients are passed to blood capillaries in the intestinal wall. Presence of typhlosole in greater part of intestine increases the surface both for digestion and absorption. Undigested food and the soil are eliminated through anus to outside in the form of worm-castings.

Circulatory system

Circulatory or blood vascular system of earthworm is a closed system consisting of blood vessels and capillaries which ramify to all parts of the body. Blood is composed of fluid plasma and colourless corpuscles. The red respiratory pigment, **haemoglobin** (or erythrocruorin) occurs dissolved in plasma. It gives a red colour to blood and aids in the transportation of oxygen for respiration.

Blood vessels

Blood vessels of *Pheretima posthuma* may be conveniently grouped into three types, *i.e.*, longitudinal, lateral and intestinal plexuses.

Longitudinal blood vessels—These are five in number and run lengthwise in the body.

1. **Dorsal vessels**—It is the largest blood vessel of body running mid-dorsally above the alimentary canal. It has thick, muscular and rhythmically contractile wall and is provided with a pair of valves in front of the septum in each segment. Blood flows through it from **backward to forward**. Behind 13th segment, dorsal vessel is a collecting vessel, receiving blood through two pairs of commissural vessels from sub-neural vessel in each segment. In each of 3rd, 4th, 5th, 6th and 8th segments, a pair of stout pulsating branches send blood to the pharyngeal nephridia, oesophagus and gizzard. In front of 13th segment (anteriorly), it distributes blood to the anterior regions of alimentary canal and through the so-called hearts to ventral vessels.

2. **Ventral vessel**—It is a large vessel, runs mid-ventrally below alimentary canal. Its walls are thin and non-contractile and valves are altogether absent. Blood flows through it posteriorly. Ventral vessel is principally a distributing vessel. Besides in each segment behind 13th, ventral vessel gives off a median ventro-intestinal vessel to intestine.

3. **Lateral oesophageal vessels**—These are two vessels lying one on either ventro-lateral side gut, running from the anterior end of body up to 13th segment. These receive a pair of ventro-tegumentary vessels in each segment. Flowing posteriorly, some of its blood passes to the supra-oesophageal vessel. Rest of blood flows backward into sub-neural vessel.

4. **Sub-neural vessel**—It is a slender vessel which runs immediately beneath the nerve cord in mid-ventral position. It extends from 14th segment upto the posterior end and is formed by the union of two lateral oesophageal vessels. Flow of blood is from infront backwards. It is a collecting vessel. It pours blood via a pair of commissurals in each segment, into dorsal vessel.

5. **Supra–oesophageal blood-vessel**—It is a short thin-walled collecting vessel lying mid-dorsally above stomach and confined to segments 9 to 13. It is connected to lateral oesophageal vessel through 2 pairs of anterior loops and to ventral vessel through two pairs of latero-oesophageal hearts. At places it divides into separate

vessels which unite to form a single vessel. It collects blood from stomach, gizzard and pumps it through lateral oesophageal hearts into ventral vessel.

Lateral or transverse blood vessels—All the longitudinal blood vessels are interconnected with one another, directly or indirectly, through numerous segmentally arranged transverse or lateral blood vessels. Lateral blood vessels of anterior region (first 13 segments) and those of posterior region (behind 13 segment) of body are described separately.

Lateral blood vessels of anterior region

(First 13 segments)

1. **Hearts**—In each of the segments 7, 9, 12 and 13 is, found a pair of large, thick, muscular and rhythmically contractile vertical vessels, called **hearts**. They pump blood from dorsal to ventral vessel, while flow in opposite direction is prevented by internal valves. Hearts of 7th and 9th segments connect dorsal and ventral vessels only, are called **lateral hearts**. Those of 12th and 13th segments connect both dorsal and supro-oesophageal vessels with ventral vessel, are designated as **latero-oesophageal hearts.**

2. **Anterior loops**—There is a pair of thin-walled, non-pulsatile, non-muscular and loop-like broad vessels, without valves, in each of the 10th and 11th segments. These vessels, known as anterior loops, carry blood from lateral-oesophageals into supra-oesophageal vessel.

3. **Ring vessels**—These are characteristic circular vessels of stomach situated within its muscular coat, about 12 vessels per segment. Through these vessels, blood of lateral oesophageals reaches the supraoesophageal.

4. **Ventro-tegumentary vessels**—Ventral vessel gives off a pair of ventro-tegumentary vessels in each segment to body wall, septa, nephridia and reproductive organs of the same segment.

Lateral vessels of intestinal region

(behind 13th segment)

1. **Commissural vessels**—There is a pair of these vessels in each segment. They collect blood from body wall and each gives off a small septo-intestinal branch to the intestine.

2. **Dorso-intestinals**—Two pairs of them in each segment carry blood of the intestine to the dorsal vessel.

3. **Ventro-intestinals**—A single, median ventro-intestinal in each segment carries blood from the ventral vessel to the ventral gut-wall.

4. **Ventro-tegumentaries**—The ventral vessel gives off a pair of ventro-tegumentaries, one on either side, posteriorly in each segment.

Intestinal Plexus

Wall of intestine contains many blood capillaries arranged in two networks, the plexus. One, the external plexus, lies on the surface or gut. It receives blood from ventral vessel through ventro-intestinals and septo-intestinals, and passes it on to the internal plexus. The latter is situated between circular muscles and enteric epithelium. Internal plexus passes on blood along with absorbed nutrients, to dorsal vessel through dorso-intestinals.

Blood Glands

In segments 4, 5 and 6, lying above pharyngeal mass and connected with pharyngeal or salivary glands, are found small, red-coloured, follicular bodies, called blood glands. Each gland consists of a mass of loose cells surrounded by a capsule with a syncytial wall. **Blood glands serve for the manufacture of blood corpuscles and haemoglobin.** They are also regarded to be excretory by some workers.

Circulation of Blood

Blood flows from behind to forward in dorsal vessel and from front to backwards in ventral, latero-oesophageal, supra-oesophageal and sub-neural vessels.

Ventral vessel is the main distributing vessel, supplying blood to all parts of body. In first 13 segments, it supplies blood to body wall, septa, nephridia and reproductive organs through ventro-tegumentaries. Behind 13th segment, it supplies blood to body wall and nephridia through ventro-tegumentaries and to gut wall through ventro-intestinals.

Sub-neural, lateral oesophageals and supra-oesophageals are the main collecting vessels. Lateral oesophageals collect blood in first 13 segments from alimentary canal, body wall, nephridia, septa and reproductive organs, and discharge into supra-oesophageal through anterior loops and ring vessels. Supra-oesophageal also collects blood from gizzard and stomach, and pours it into ventral vessel through latero-oesophageal hearts. Subneural collects blood in the intestinal region from ventral body wall and sends into dorsal vessel through commissurals.

Dorsal vessel functions both as a collecting and a distributing vessel. In the intestinal region, it collects blood through dorso-intestinals from gut wall and through commissurals from sub-neural vessel, septa and nephridia. In first 13 segments, it distributes some blood through branches to alimentary canal and pours the remaining blood through hearts into ventral vessel.

Digested food absorbed through the intestinal wall is distributed to different parts of body by the circulatory system, whereas CO_2 and nitrogenous wastes are carried to nephridia, skin and coelomic fluid for elimination.

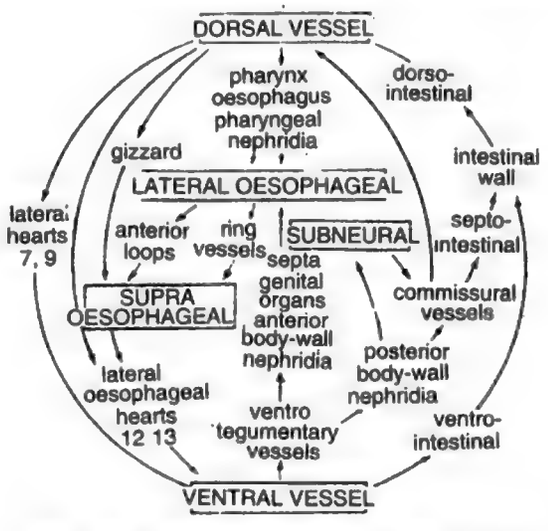


Fig. : *Pheretima*. Course of circulation of blood.

Excretory or Nephridial System

In *Pheretima*, excretion is effected by segmentally arranged nephridia. These are typically unbranched and their inner ends open into coelom by a ciliated funnel, called **nephrostome.** Such a nephridium, opening by a ciliated funnel, is termed as **metanephridium**. In *Pheretima*, nephridia occur in all body segments except the first three. According to their location in body, these are distinguished into 3 types—**Pharyngeal, Integumentary** and **Septal**.

Pharyngeal nephridia

These occur as paired tufts on either side of pharynx and oesophagus in the 4th, 5th and 6th segments. Each tuft consists of hundreds of coiled branched tubules **without nephrostomes.** In each tuft, the terminal ducts of all tubules join to form a single thick-walled common duct. Thus there are 3 pairs of common pharyngeal nephridial ducts, which run anteriorly parallel to the ventral nerve cord. Ducts of 4th and 5th segments open into pharynx, while that of 6th segment open into the buccal chamber. **Pharyngeal nephridia are thus enteronephric.**

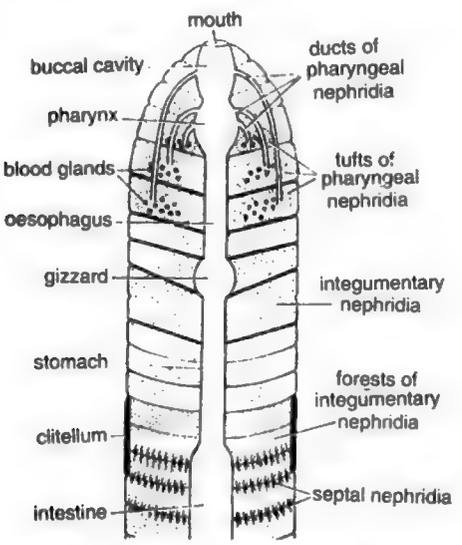


Fig. : *Pheretima*. Location of the three types of nephridia.

Integumentary nephridia

These nephridia lie scattered on the entire inner or parietal surface of body wall in each segment, except the first two. There are 200–250 nephridia in each segment but the segments of clitellum (segments 14 to 16), their number increases to more than 2000. Integumentary nephridia are V-shaped and **lack nephrostomes.** Their terminal ducts open on body surface independently through minute openings known as nephridiopores. Integumentary nephridia are thus **exonephric.**

Septal nephridia

These are the largest nephridia of *Pheretima*. They are attached to both the faces of each intersegmental septum behind 15th segment.

A typical septal nephridium consists of three main parts—Nephrostome, body and terminal duct.

Nephrostome is a ciliated funnel communicating with the coelom. Nephrostome leads into the main body of nephridium through a short, narrow and ciliated tube-like neck. Body consists of two parts, a short straight lobe and a long twisted lobe with a narrow apical part. The twisted lobe consists of a proximal limb and a distal limb. Proximal limb is joined to the neck. Distal limb of nephridium ends in terminal duct. Terminal ducts open into a pair of septal excretory canals. These canals discharge their contents into a pair of supra-intestinal excretory ducts. These ducts open into intestine in each segment. Septal nephridia are thus also **enteronephric.**

Physiology of excretion

Nephridia are abundantly supplied with blood vessels. Their gland cells extract excess of water and nitrogenous wastes from blood. Septal nephridia also eliminate excretory material from coelomic fluid. Integumentary nephridia being exonephric, discharge excretory material to outer body surface through nephridiopores. Pharyngeal and septal nephridia being enteronephric, discharge excretory material into lumen of alimentary canal, from where the excretory wastes are eliminated with faeces. Terrestrial earthworms excrete urea (ureotelic). However earthworms are less ureotelic than other terrestrial animals. Chloragogen cells are also said to be concerned with deamination of proteins, formation of ammonia and synthesis of urea.

Respiration

Respiration takes place by diffusion of gases through general body surface. Gaseous exchange takes place between blood capillaries of outer moist epidermis and surface film of moisture. Haemoglobin dissolved in plasma of blood acts as a respiratory pigment, transporting O_2 to the body tissues.

Nervous system

Nervous system is well developed and concentrated. It consists of three parts—Central, Peripheral and Sympathetic nervous systems.

Central nervous system

It comprises an anterior nerve ring and a posterior ventral nerve cord. Nerve ring comprises paired cerebral ganglia, circumpharyngeal connectives and subpharyngeal ganglia.

A pair of closely united white, pear-shaped cerebral or supra-pharyngeal ganglia, forming the so-called **brain**, lie dorsally in the 3rd segment. A pair of thick stout circum-or peri-pharyngeal connectives arise from them laterally and meeting ventrally in a pair of fused sub-pharyngeal ganglia beneath the pharynx in 4th segment. In this way, a complete nerve ring is formed around pharynx. Ventral nerve cord arising from the sub-pharyngeal ganglia, runs backwards in mid-ventral line to the posterior end of body. Ventral nerve cord appears to be single but it is double, consisting of two compactly united right and left cords. Each segmental ganglion also represents the fusion of a pair of ganglia, one belonging to each cord of the double ventral nerve cord. Histologically, the nerve cord consists of nerve fibres and nerve cells. Externally the nerve cord is covered by a layer of **visceral peritoneum**, beneath which lies a thin layer of **longitudinal muscle fibres**, surrounding a fibrous capsule of

epineurium. Fibres form the core of the cord. In the regions of segmental ganglia, the two cores of nerve fibres are completely fused along the middle line. On the sides and below cores of nerve fibres lie the nerve cells. These are of two types—**motor neurons** and **association neurons**. Nerve cells occur more in the ganglia. Nerve cells and nerve fibres lie embeded in a mass of connective tissue, called neuroglia.

Peripheral Nervous System

Each cerebral ganglion gives off laterally 8 to 10 nerves which innervate the prostomium and buccal chamber. Nerves from peripharyngeal connectives supply the peristomium and buccal chamber, while nerves from sub-pharyngeal ganglia supply structures in the 2, 3 and 4 segments. Each segmental ganglion of ventral nerve cord gives off 3 pairs of lateral nerves, one pair in front and two pairs behind the row of setae, which innervate the gut wall, body wall and other internal organs of their segments.

Nerves are of **mixed type**, consisting both afferent or sensory fibres and efferent or motor fibres.

Sympathetic nervous system

It consists of an extensive nerve plexus spread beneath epidermis, within muscles of body wall and on alimentary canal. These plexus are connected with the peripharyngeal connectives.

Sense organs

Earthworms have well-developed sense organs or receptor organs which are quite simple in structure, consisting of a single cell or a group of specialized **ectodermal cells**. *Pheretima* has three types of sense organs—Epidermal receptors, Buccal receptors and Photo-receptors.

Epidermal receptors

They are distributed all over epidermis but are more abundant on the lateral sides and ventral surface of body. Each receptor has an elevated cuticle covering a group of tall, slender and columnar **receptor cells**, bearing small hair-like processes at their outer ends and connected with nerve fibres at their inner ends. They are surrounded on all sides by ordinary **supporting epidermal cells**, are separated from each other by spaces, have nuclei at different levels and possess internally a few basal cells. They are tactile in function and according to some, they also respond to chemical stimuli and changes in temperature.

Buccal receptors

These are confined to the epithelium of buccal chamber. They are similar to epidermal receptors except that they possess broader outer ends, better developed sensory hairs and more deeply situated nuclei. They are **gustatory** and **olfactory** and probably also respond to chemical stimuli.

Photo-receptors

Photo-sensitive organs, restricted only to dorsal surface, are more numerous on prostomium and peristomium and gradually reduce in number towards posterior end of body. They are totally absent in clitellum. Each photoreceptor consists of a single ovoid ceil, with a nucleus and clear cytoplasm containing a network of **neurofibrillae** and a small transparent L-shaped **lens** or **optic organelle** or **phaosome**, made up of a hyaline substance. Lens focusses light rays from all directions on neurofibrils. Neurofibrils converge to an afferent nerve fibre which leaves the cell at its base to join the central nervous system. Photoreceptors enable worms to judge the intensity and duration of light.

General behaviour

Earthworms do not have special sense organs, yet they show some sort of behaviour to all kinds of stimuli such as touch, jarring, light and noxious chemicals. Their epidermal receptors are extremely sensitive to touch (tactile) and mechanical vibrations. When touched, their body immediately rolls over.

With the help of buccal receptors, earthworms display chemical responses comparable to taste (gustatory) and smell (olfactory), in the choice of food. Unpleasant and irritating chemical vapours cause them to withdraw immediately into the burrow. When irritated they eject coelomic fluid through the dorsal pores.

Photo-receptors, occurring in clusters enable worms to judge the intensity and duration of light. Earthworms are **negative phototrophic** to strong light and **positive phototrophic** to weak light. They avoid strong day light and will atonce recede into burrow if flashed with a torch.

Earthworms respond to very low and very high temperatures by burrowing deeper in soil. They like moisture and avoid dryness, but come out of their burrows when they get flooded during rainy season. They give no evidence of sense of hearing and evidently do not perceive mere sound vibrations in air.

Reproductive System

Earthworms do not reproduce asexually. The earthworms **monoecious** (**hermaphrodite**) but they cannot fertilize their own eggs because they are **protandrous**. As a rule, cross-fertilization takes place. It is preceded by copulation and cocoon formation.

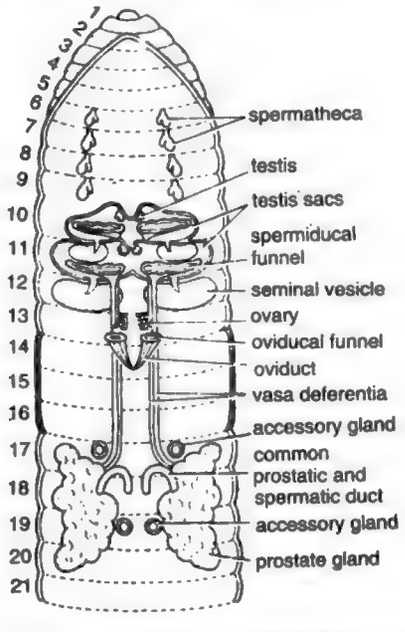


Fig. : *Pheretima*. Reproductive system.

Male reproductive organs

These include testes, testis sacs, seminal vesicles, vasa deferentia, prostate glands and accessory glands.

Testes—Two pairs of minute and lobed testes are present, one pair in 10th and the other pair in 11th segments. They lie ventero-laterally beneath the alimentary canal, close to mid-ventral line, on either side of nerve cord and attached to the anterior wall of their respective testis sacs. Testes are well formed only in young worms, but become degenerated in adults.

Testis sacs—Both the testes of each segment are enclosed within a wide, thin-walled testis sac. Thus, there are two testis sacs situated in segments 10 and 11. Each testes sac encloses a pair of testes and a pair of ciliated spermiducal funnels and also communicates behind, by a pair of tubular connections, with two seminal vesicles of succeeding segment. Testis sac of 11th segment is large enough so as to enclose also the seminal vesicles of that segment.

Seminal vesicles—There are two pairs of large, seminal vesicles lying in segments 11 and 12 respectively. They are also referred to as septal pouches since they grow as outgrowths of the septa. Testis sac of 10th segment communicates with seminal vesicles of 11th segment and testis sac of 11th segment with seminal vesicles of 12th segment. Seminal vesicles of 11th segment lie enclosed within testis sac of the same segment, while those of 12th segment lie free.

Spermiducal funnels—There are two pairs of ciliated **spermiducal funnels** (or spermosettes), one of them lying behind each testis in the same segment and enclosed within the same testis sac.

Vasa deferentia—Each spermiducal funnel leads behind into a slender, ciliated, thread-like sperm duct or vas deferens. Two vasa deferentia of same side run close together posteriorly along the ventral body wall up to 18th segment to join the prostatic duct.

Prostate glands—Prostate glands are a pair of flat, solid, irregular and lobulate masses, lying one on either side of gut and extending from 16th or 17th segment upto 20th or 21st segment. Immediately on emergence of prostatic duct from the inner side of gland, it is enclosed in a common muscular sheath, along with the two vasa deferentia on its own side, forming a common spermatic and prostatic duct, within which the three tube remain separate. Both common ducts curve inwards to open to the exterior independently by a pair of male genital pores ventrally on 18th segment. Prostate glands manufacture a fluid, the prostatic fluid, of unknown function.

Accessory glands—In each of the 17th and 19th segments, is found a pair of rounded white fluffy masses, the accessory glands, on ventro-lateral body wall, one on either side of nerve cord. They open to the exterior by a number of ducts on two pairs of genital papillae, situated externally upon the 17th and 19th segments, one on either side of mid-ventral line. Their secretion helps probably in uniting the two worms during copulation.

From testes, spermatogonia or sperm-mother cells are shed into testis sacs. From here they enter seminal vesicles to undergo maturation and develop into spermatozoa. Mature sperms move back into testis sac, enter spermiducal funnels, travel along vasa deferentia and finally pass out through genital pores during copulation.

Female reproductive organs

The female reproductive organs consists of ovaries, oviducal funnels, oviducts and spermathecae.

Ovaries—A pair of small white digitate ovaries lies in 13th segment attached to the posterior face of septum 12/13 in form of it, one on either side of ventral nerve cord. Each ovary is a white compact mass made of finger-like processes in which ova are arranged in a linear series in various stages of development.

Oviducal funnels—A large saucer-shaped oviducal funnel, with much folded and ciliated margins, lies immediately behind each ovary in the 13th segment.

Oviducts—Each aviducal funnel leads behind into a short conical ciliated tube, the oviducts. The two oviducts run backwards, perforate septum 13/14 and converge to meet in ventral body wall beneath nerve cord, forming a very short common oviduct. It opens to the exterior through the female genital aperture, situated mid-ventrally on 14th segment.

Spermathecae—There are 4 pairs of small flask-shaped structures, called **spermathecae** or **receptacula seminalis**. These are present ventro-laterally, one pair in each of the segments 6, 7, 8 and 9. Each spermatheca has a broad pear-shaped body, the ampulla, and a short narrow neck, which gives off a narrow elongated blind caecum or diverticulum before opening to the exterior. Thus 4 pairs of spermathecae open to outside by 4 pairs of separate spermathecal pores situated ventero-laterally in the grooves between 5/6, 6/7, 7/8 and 8/9 segments, respectively. Spermathecae receive sperms from another worm during copulation, and store them in their diverticula in *Pheretima* and in ampullae in other earthworms.

Mature ova shed from ovaries are entangled by oviducal funnels, travel along oviducts, and pass out to the exterior through the female genital aperture, to be laid inside the cocoon.

Copulation and Fertilization

Earthworms are bisexual, still self-fertilization does not occur because they are **protandrous**. A reciprocal cross-fertilization of one worm are transferred to another during a process, termed copulation. During copulation, two worms apply each other by their ventral surfaces with head endo pointing in opposite directions, so that the male genital pores of each lie against a pair of spermathecal pores of other. Areas surrounding the male genital apertures are raised into papillae, which are inserted successively from behind to forward into the spermathecal pores of other worm and discharge spermatozoa, which are stored in spermathecae.

After this mutual interchange of sperms, the two worms separate and later lay their eggs in cocoons. **Fertilization is thus external taking place in the cocoons.**

Cocoon formation

Cocoon is secreted as a viscid and gelatinous substance by clitellar glands, forming a broad membranous

band or girdle around clitellum. It hardens gradually on exposure to air into a tough but elastic tube which becomes the cocoon or egg capsule. A slime tube is also secreted by epidermal mucous cells of clitellum over cocoon. As the worm wriggles behind, the slime tube and cocoon are slipped forward over the head. On its way the cocoon receives ova from female genital pore and sperms of other worm from spermathecae, so that cross-fertilization is ensured and zygotes are formed. An albuminous fluid is also deposited inside cocoon by the glands of anterior segments of body. Finally, when cocoon is thrown off the head, its elastic ends close up and a yellowish rounded cocoon is formed.

Fertilization occurs after the cocoon has been deposited in a moist place. Cocoon of *Pheretima* is a small, spherical body. Cocoon formation takes place in *Pheretima* in summer, especially during and after the monsoon. Many cocoons may be formed in succession after each mating, so that all sperms stored in the spermathecae are not passed out at once.

Development

Cocoon may contain many fertilized eggs but only one embryo develops, growing at the expense of other eggs serving as nurse cells and albumen stored in cocoon. Cleavage is holoblastic and unequal and development is direct without any free larval stage. A hollow blastula is formed and later a gastrula by invagination. Mesoderm develops from two large cells of blastula, called **mesoblasts**. They divide to form two mesoblastic bands, which later give rise to the coelomic epithelial lining. Young worms, when fully grown, crawls out of cocoon in about two or three weeks. Newly hatched young worm receives no parental care and resembles the adult except for size and absence of clitellum.

Regeneration and Grafting

Earthworms do not reproduce asexually, but they great capacity for regeneration. If ends of body are cut accidently or removed experimentally, a head or tail is regenerated to replace the lost part.

Earthworms can also be grafted like *Planaria*. Experimentally, some abnormal types have been produced such as worms with two tails, short worms by grafting together two terminal parts or exceptionally long worms by joining end to end pieces of several worms. However such freaks do not survive as they cannot feed.

Economic Importance

Earthworms are of great economic importance to man. They are directly or indirectly useful to us as follows :

1. **As bait and food**—All over the world, they are used as bait for fishing. They form the best food of fish in aquaria. They are also used a food by various uncivilized people in many parts of world. They also form food for certain birds, frogs, reptiles, centipedes and other predatory invertebrates

2. **In Agriculture**—Earthworms are in general beneficial to agriculture. Although they may sometimes do damage to young and tender plants, yet they are good friends to the gardner and farmer as they. Contihuously plough and manure the soil. Their habit of burrowing and swallowing earth increases fertility of soil. Their burrows permit penetration of air and moisture in porous soil, improve drainage, and make easier the downward growth of roots. Earthworms are continuously dragging dead leaves into their burrows to eat them. They are partially digested and their remains are thoroughly mixed with the castings, thus add humus to soil. Excretory wastes and other secretions of worms also enrich soil by adding nitrogenous matters that form important plant food. One acre of ground may contain 50000 earthworms and the quantity of earth brought up from below and deposited on the surface as worm castings has been estimated by Darwin to be as 18 tons per acre per year. In recent years, there is stress on the importance of culturing earthworms to build up soil to a high degree of fertility.

3. **In medicines**—Earthworms were used variously as medicines in the past. Hamdullah Mustaufi of Qazwin in 'Naizat-ul-Qutub' written in A.D. 1340, and Damari in Hayat-ul-Haiwan' written in A.D. 1371 told about medicines prepared from earthworms to cure stones in bladder, pyorrhoea, piles, rheumatism, sexual impotency etc. Even to this day the Chinese, Japanese and Indians are said to use earthworms in various fancy medicines.

4. **In laboratory**—Earthworms are easily available and are of convenient size for dissections. They are, therefore, universally employed for class-room studies.

5. **Harmful worms**—In some cases, earthworms become harmful. Exceptionally, their burrows may cause loss of water by seepage from ditches in irrigated lands. Their castings on sloping lands tend to be washed away by rain and thus contribute to soil erosion, though to a

Significant facts of Earthworm

Earthworms are well-adapted for a subterranean or burrowing mode of life.

- Elongated, slender, cylindrical and streamlined body is well-suited for burrowing in soil.
- Setae and musculature serve for locomotion as well as for anchoring body firmly in burrow.
- Secrete mucus for plastering the internal walls of burrow.
- Coelom fluid oozing through dorsal pores keeps skin moist for gaseous exchange in the absence of respiratory organs.
- Amoebocytes of coelomic fluid kill harmful bacteria and other parasites and protect body.
- Nocturnal and burrowing habits provide safety from predators.
- Sensory organs such as many photosensitive organs are present on dorsal surface, numerous on prostomium and peristomium.
- Earthworms are negatively phototrophic to strong light and positive to weak light.
- Hermaphroditism and regeneration ensure continuity of species against many hazards in life.
- Formation of cocoon for fertilization and development are adaptations for reproduction on dry land.
- Their habit of burrowing and swallowing soil increases fertility of soil in many ways, thus they are friends of farmers.

lesser extent. Certain species live as external parasites of frogs. Sometimes, they bury in the dead bodies of buried animals and bring the disease-germs to surface, where they may infect other animals. Earthworms are said to serve as intermediate hosts in the transmission of some parasites, such as tapeworm (*Amoebotaenia sphenoides*) and gapeworm (*Syngamus*) of chicken and lung nematode (*Metastrongylus elongatus*) of pigs. The latter parasite carries a virus, which together with a bacterium, causes hog-influenza or swine influenza. Some species become pests of plants. *Pheretima elongata* is suspected of damaging the roots of the Betel-wine (Piper Betel) in Coimbatore. *Malabaria pododicola* and *Aphanascus oryzivorus* are said to damage the roots of paddy in Malabar. A species of *Perionyx* damages cardamon stems grown on the Anamalai Hills.

OBJECTIVE QUESTIONS

1. The arrangement of numerous setae in a ring in each segment of *Pheretima* is known as—
   (A) Lumbricine
   (B) Oligochaetine
   (C) Otochaetine
   (D) Perchaetine
2. In earthworm, the first segment in which the mouth is situated is known as—
   (A) Prostomium
   (B) Peristomium
   (C) Protostomium
   (D) Stomium
3. Which of the following is the primary characteristic of phylum Annelida ?
   (A) Metameric segmentation
   (B) Excretion by flame cell
   (C) Trochophore larva in life cycle
   (D) Body covered by ciliated epithelium
4. In earthworm, which of the following cells function like that of liver cells of vertebrates ?
   (A) Amoebocytes
   (B) Mucous cells
   (C) Chloragogen cells
   (D) Epidermal cells
5. What term is used for the nephridia which discharge their excretory products into the lumen of gut ?
   (A) Enteronephric
   (B) Exonephric
   (C) Exocrine
   (D) Holocrine
6. In some earthworms, calciferous glands are restricted to—
   (A) Oesophagus
   (B) Rectum
   (C) Stomach
   (D) Typhlosole
7. Which of the following nephridia are exonephric in earthworms ?
   (A) Pharyngeal
   (B) Septal
   (C) Integumentary
   (D) Pharyngeal and integumentary
8. In earthworm, the fertilization takes place in—
   (A) Oviduct
   (B) Spermathecae
   (C) Clitellum
   (D) Cocoon
9. Which of the blood vessel is the largest in earthworm and possesses valves ?
   (A) Sub-neural vessel
   (B) Oesophageal vessel
   (C) Dorsal blood vessel
   (D) Ventral blood vessel
10. Earthworm has no skeleton but during burrowing the anterior end becomes turgid and acts as a hydraulic skeleton. It is due to—
    (A) Setae
    (B) Coelomic fluid
    (C) Circular muscles
    (D) Longitudinal muscles
11. In earthworm typhlosole helps—
    (A) To accommodate dorsal blood vessel
    (B) To increase absorptive area in alimentary canal
    (C) To secrete enzymes
    (D) None of the above
12. Photoreceptors of earthworm are present on—
    (A) Dorsal surface
    (B) Ventral surface
    (C) Clitellum
    (D) All the above
13. Lateral hearts of earthworm are found in the segments—
    (A) 6th and 8th
    (B) 8th and 9th
    (C) 7th and 9th
    (D) 5th and 7th
14. What is the function of porphyrin in earthworm ?
    (A) To protect against harmful germs
    (B) To help in respiration
    (C) To help in excretion
    (D) To protect against harmful ultraviolet rays
15. Spermathecal in earthworm are meant for—
    (A) Producing sperms
    (B) Storing its own sperms
    (C) Storing sperms of other earthworm after copulation
    (D) None of the above

ANSWERS

1. (D) 2. (B) 3. (A) 4. (C) 5. (A)
6. (C) 7. (C) 8. (D) 9. (C) 10. (B)
11. (B) 12. (A) 13. (C) 14. (D) 15. (C)

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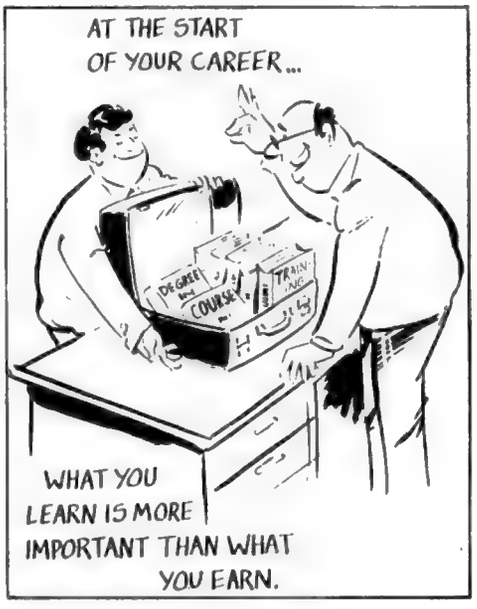


SNAKES

Introduction

Snakes have long, cylindrical body without limbs, movable eyelids and tympana. They are insensitive to air-borne sound but can perceive earth-borne vibrations. Eyes of the snakes are covered with a transparent scale and lack eyelids. This enables them to give an unwinking stare. Tongue is slender, forked and protrusible. It acts as an additional organ of smell. It flicks in and out, carrying chemicals from air or ground to sense organs (called **Jacobson's organs**) located in the roof the buccal cavity. Pit vipers and some boas have heat detecting organs on the head. These enable them to strike warm-blooded prey accurately in dark nights or in deep burrows. Jaw bones are movable, enabling the snakes to swallow a large prey. Long flexible ribs help maintain body shape.

The snakes are generally nocturnal and commonly carnivorous. Snakes hibernate during winter. They periodically cast off their horny layer of skin as a continuous slough. They often produce a hissing sound by forcibly expelling air through the nares after inflating the lungs. Snakes run quite fast on rough surface but are helpless on hard smooth surface. Most snake species move by throwing the body into curves. Scales on the ventral side or curves of the body itself, provide traction. All snakes swim well by lateral undulations of the body and most of them can climb also.

Majority of snakes are non-poisonous and are useful as they feed on rodents in crop fields. They may bite but do not have poison to inject into the victim. Poisonous snakes have additional poison teeth, called fangs, specialised for injecting poison from poison glands present in their head.

Unlike birds and mammals, snakes grow continuously, though at decreasing rates, throughout their lives. All snakes feed on other animals, especially vertebrates. The commonest prey are mammals, birds and frogs; others include earthworms, insects, fish, bird's eggs. Prey is always swallowed whole; no snake has teeth adapted for chewing. In several groups the **salivary glands** have become modified into poison glands, the venom being delivered by means of hollow or grooved fangs.

Snakes reproduce by egg laying (Oviparity). Sea-snakes are generally viviparous. Little parental care is practiced but in some cases the eggs are guarded by the parent.

Snakes of India

The common poisonous snakes of India are **Cobra, Krait, Viper** and **Sea-snakes**. The non-poisonous snakes are **Typhlops** (Blind snake), **Python**, **Ptyas** (Rat snake), **Tropidonotus** (Common pond or grass snake), **Eryx** (Sand Boa), **Dendrophis** (Tree snake).

Poisonous Snakes

Cobra—It is highly venomous snakes of the family Elapidae that expand the neck ribs to form a hood. Cobras are found in warm regions. They are favourites of snake charmers, who tease them into assuming the upreared defense posture. The snake sways in alert response to the charmer's movements, not to the sound of his pipe–snakes are deaf to high frequencies.

Common Indian Cobra is *Naja naja* and kills several people every year, mostly because it visits houses at twilight to catch rats. In India, this species has a spectacle-like mark on its exceptionally wide hood.

Cobras are extremely variable in colouration and markings. Three races are recognised on the basis of the hood pattern. The binocellate Cobra of peninsular India (*Naja naja naja*) is yellowish, brownish or black above with or without a black and white mark on hood, a black and white spot on the inside of the hood with one or two black crossbars below hood. Sri Lankan and South Indian cobras are usually of shades of brown with well-defined hood marks. Cobras of North India are more often black.

Monocellate Cobra (*Naja naja kaouthia*) has only a single yellow or orange O-shaped mark on the hood. The Black Cobra of North is *Naja naja oxiana*.

King Cobra—The world's largest venomous snake is the King cobra, or hamadryad (*Ophiophagus hannah*). It preys chiefly on other snakes. The primary feeding cue is scent. King cobra has earned for itself an unenviable reputation for aggressiveness and courage and is largely **diurnal**.

It occurs in the dense forests of the Western Ghats, plains an estuaries of Orissa, West Bengal and Assam. It is not a common snake in India.

The King cobra, one of the very few **nest-building** snakes, drags dead vegetation into a low heap by bending its body. The eggs are laid in a cavity at the centre of nest. Other snakes deposit their eggs in holes they have scooped out of sand or soft earth with their snout.

The spitting of venom by certain African cobras, the ringhals (*Hemachatus haemachatus*), and the black-necked cobra (*Naja nigricollis*) is a purely defensive act directed against large enemies. A fine stream of venom is forced out from each fang. Usually a spitting cobra raises its head and the forepart of its body in the characteristic cobra defensive posture prior to spitting, but venom can be ejected from any position. The effect on skin is negligible; the eyes, however, may be severely damaged, and blindness can result unless the venom is washed out quickly.

The poison of cobra acts mainly as a neurotoxin and blood and cell destroyer. The neurotoxin paralyses the respiratory centre and is the chief cause of death. Other

effects are loss of clotting power of the blood and destruction of red blood cells.

Krait—The common Indian krait is scientifically known as *Bungarus Caeruleus*. They have lustrous black or bluish black above with paired narrow white crossbars indistinct or absent anteriorly. The common krait inhabits fields, low scrub jungles and is common in the vicinity of human habitation, often taking up residence inside houses. It is **nocturnal** and of a placid temperament, biting usually only under provocation. Many instances are on record of people sleeping on the ground being bitten when unknowingly rolling on or placing a leg or hand in their sleep on a Krait moving nearby.

Krait feeds mainly on snakes including other kraits. Occasionally feeds frogs, lizards, rats etc. kraits show **Cannibalistic** tendencies. The secretion of the anal glands which has a disagreeable smell to man may perhaps help in recognition.

The venom is more toxic than that of the cobra and acts both as a **neurotoxin** and **haemotoxin**, para-lysing the respiratory centre, and centres concerned with the lips, tongue, throat and voice and phrenic nerves. The red blood corpuscles are destroyed as also the lining of the smaller blood vessels. The major cause of death is **asphyxia** through paralysis of the respiratory centre. Krait venom is considered to be 15 times more virulent than the cobra's, and the krait is one of the deadliest among the poisonous snakes of the world.

Symptoms are a 'fiery' pain at the site of the bite which disappears after some time, later violent abdominal pain probably due to haemorrhage and paralysis sets in. The eyelids, and lower lip droop and the person is unable to walk and to breathe. Often there is no immediate reaction and the bite is ignored with fatal results. Death may result in five to twelve hours after the bite.

Banded Krait—Banded krait is scientifically known as *Bungarus fasciatus*. This has alternating yellow and black bands. This krait can be confused with the harmless (non-poisonous) Yellow-banded Wolfsnake (*Lycodon fasciatus*). It can be distinguished by the enlarged vertebrals entire subcaudals, ridged spinal area and blunt tail. Occurs fairly commonly throughout the North-east peninsular India and northern parts of India. It is largely **nocturnal**, and is found in grass, pits or drains during the day. Frequents moist places and the vicinity of water. It is extremely sluggish and remains lethargic even under provocation. Most commonly seen during the rains.

It feeds mainly on snakes and among those eaten are rat-snake or dhaman. This snake is poisonous as other common kraits. Its poison is said to be less virulent than cobra poison.

Russell's Viper (*Vipera russelli*)—Its head is covered with small scales and without shields. Body massive, cylindrical, narrowing at both ends, head flat triangular with short snout. Widely distributed in Indian sub-continent and north to east Himalayas. Uncommon to rare in Ganges valley. It is common in inhabited areas, the attraction being the rodents.

Normally sluggish and does not strike readily unless irritated. Usually it contends itself with hissing sounds. It is largely **nocturnal**. The young are more prone to be aggressive and to bite. The young are often cannibalistic. The Russel's viper is **viviparous**. Fangs are movable and become errected when mouth opens.

The venom is transparent, acidic in reaction and tastes like gum arabic. The poison acts as a depressor of the vasomotor centre and a destroyer of the blood. The blood pressure drops and heart weakens. The red blood corpuscles are destroyed, the clotting power of the blood is reduced and the lining of the blood vessels destroyed leading to extensive internal haemorrhages with pain and vomiting and bleeding from the body's openings.

Saw-scaled Viper (*Echis carinatus*)—Distinguished from other Indian snakes by the absence of shields on the head. Mainly inhabits arid country. In India, it is commonly found south and west of Ganges. Though essentially a desert snake, it occurs in semi-desert and broken scrub country. It is an alert little snake, largely **diurnal**, and is capable of quick movement when necessary. Feeds largely on centipedes, scorpions, larger insects, mice, shrinks, geckos and frogs.

The Saw-scaled viper is **viviparous** producing 3 to 15 young at a time. The fangs of this snake are remarkably long for its size. The almond shaped poison glands are placed behind the eye. The poison acts mainly as an anti-coagulant, a destroyer of blood cells and lining of blood vessels, a cardiac depressor and generally as a depressor to nerve cells. The local symptoms are similar to those of the Russel's viper. The venom acts directly on cardiac muscles also. Death results from heart failure.

Green or Bamboo Pit Viper (*Trimeresurus gramineus*)—The head is flattened and appears unduly broad owing to the constricted neck. Tail is **prehensile**. It is found in forests of hills. In the Western Ghats of India, they are usually seen during rains. The poison's action is feeble but painful and swelling of the bitten part, nausea, vomitting and fever, the symptoms diappearing in about 48 hours. It is **viviparous**.

Himalayan Pit Viper (*Agkistrodon himalayanus*)—The loreal pit identifies it as a pit viper, from other pit vipers by the presence of large shields instead of uniform small scales on top of head. Occurs commonly in the Western Himalayas. It is **viviparous**. The poison is not particularly virulent and the bite of the snake is not fatal to man.

Shaw's Sea-snake (*Lapemis curtus*)—The only Indian sea-snake with parietal shields on head broken up into smaller shields. It is commonly found in Persian Gulf to Malay Archipelago. Common along the Malabar and Tamil Nadu coasts. It is **viviparous**. Its poison action is similar to that of cobra, but the respiratory failure is more pronounced.

Hook-nosed Sea-snake (*Enhydrina schistosa*)—The oar-shaped tail distinguishes this from other sea snakes. It is abundant on both coasts of the Indian peninsula. It is the commonest. Indian sea snake being very numerous all along the coast and ascending considerable distances on the tidal rivers. They feed entirely on fish. Its poison is said to be ten times more potent than cobra venom. It is **viviparous**.

Yellow Sea-snake (*Hydrophis spiralis*)—It is largest among the sea snakes and tail is laterally compressed.

Head in young is black with more or less distinct yellow horseshoe mark on the crown. These are abundant in the Persian Gulf and common on the east coast. Feeds largely on eel fishes. It is highly poisonous and **viviparous**.

Non-Poisonous Snakes :

1. **Blind Snake** (*Typhlina bramina*)—All *Typhlina* have a slender worm-like shape and undifferentiated body scales. Eyes indistinct. Other species of Blind snakes are *Typhlina acutus* and *Typhlina diardi*.

2. **Ocellate rough-tailed snake** (*Uropeltis ocellatus*)—Distinguished by the obliquely truncated tail. Neck region similar in girth than the body. Eye small and contained in ocular or eye-shield. Feeds almost exclusively on earthworms. It is ovo-viviparous.

3. **Indian Python** (*Python molurus*)—Normally a jungle dweller occurring in dense as well as in open forests. Feeds on mammals, birds, reptiles, but seems to prefer mammals. Pythons are long lived. Python has vestigial pelvic girdle.

4. **Dhaman or Common Ratsnake** (*Ptyas mucosus*)—It is a common in all parts of India. **Diurnal** in habit. An unusual behaviour, which has not been recorded in any other species of Indian snakes, is the '**Combat Dance**', between males.

5. **Tree Snake** (*Dendrelaphis tristis*)—Common in the Himalayan foothills. It is an active snake and ascends trees with amazing speed.

6. **Common Wolfsnake** (*Lycodon aulicus*)—It is most often seen near and in human habitation. The readiness with which it bites and its habit of living in houses make this snake responsible for a large number of snake bite cases in India every year. It is most often confused with the common krait from its almost identical colour pattern. It is non-poisonous. Any fatality resulting from bite of wolf snake is purely the result of fright.

7. **Boa** (*Eryx johni*)—Widely distributed in the plains of India. It appears to be of a gentler temperament being a particularly inoffensive creature.

8. **Flying Snake** (*Chrysopelea ornata*)—Commonly found in the forests of the Andamans and Western Ghats. It is an arboreal snake and **diurnal** in habit. Several instances are available of their ability to spring horizontally and upwards and to glide from a height to the ground or to another tree.

9. **Water Snake** (*Enhydris enhydris*)—A thoroughly aquatic snake frequenting rivers, estuaries, lakes, marshes and perhaps wet fields. Feeds mainly on fish.

Poison Apparatus

All the poisonous snakes have in their heads a poison apparatus which is not found non-poisonous snakes. This apparatus includes (1) a pair of poison glands, (2) their ducts, (3) fangs and their muscles.

1. **Poison Glands**—Two sac-like poison glands are situated one on either inner side of the upper jaw, below the eyes and somewhat behind them. These are possibly the modified **superior labial** or **parotid salivary glands**. Each gland is thickly encapsulated with fibrous connecting tissue and mostly covered by a fan-shaped constrictor muscle, often referred to as **temporal** or **massetor**. Its stretching during biting squeezes poison from glands into its ducts.

2. **Poison Ducts**—A narrow poison duct leads anteriorly from each poison gland to the base of a poison fang to enter its groove or canal.

3. **Fangs**—Fangs are certain specialized teeth attached to maxillary bones. They are long, curved, sharp and pointed. They serve as hypodermic needles for injecting poison into the body of victim. When a functional fang is lost or damaged, it is replaced by one of the reserved fangs. On the basis of structure and position, 3 types of fangs occur in poisonous snakes :

(a) **Solenoglyphous**—In vipers and rattle snakes, a large functional fang occurs on the front of maxilla. Its base is covered on all sides by a sheath containing a few reserve and developing fangs. The fang is movable and turned inside to lie close to the roof of mouth when it is closed. A hollow poison canal through the fang opening at the tip.

(b) **Proteroglyphous**—In cobras, kraits, coral and sea snakes, fangs are small, at the front of maxillae and **permanently erect**. Each fang is grooved all along its anterior face.

(c) **Opisthoglyphous**—In some poisonous snakes, in family Colubridae, fangs are small, lie at the back of maxillae and each grooved along its posterior border.

Significant Facts of Jaws and Fangs

- The jaws of snakes are highly mobile and are usually heavily armed with teeth.
- The upper jaw can move to and fro on hinged joints and can also rotate slightly.
- In most snakes, the upper jaw is connected to the lower jaw by a joint that acts as a pivot point, and in eating all toothed bones on one side of the mouth move forward as a unit.
- In some tree snakes, the connection between upper jaw and the quadrate bone is lost, and there are four independent units rather than two.
- The maxillary bone of most snakes is elongated, with many teeth, but in the family viperidae (vipers, pit vipers and rattle snakes), only one functional fang remains on a short, blunt, rotable maxillary. The position usually occupied by the maxillary has been taken by the pterygoid bone.
- In the family Elapidae (Cobras and relatives) the maxillary bears a single fang in a fixed position, sometimes followed by a few smaller, solid teeth. The posterior one or two teeth on maxillary have enlarged and changed, usually into fangs to conduct the flow of venom. These are the rear—fanged snakes.
- The two rami of lower jaw are loosely connected anteriorly by an elastic ligament.

Snake Venom

Snake venom or poison is secreted by certain poison glands found in the head region of snakes and injected in the body of bitten prey through the fangs serving as hypodermic needles. It is clear sticky liquid of faint yellow or greenish colour. It is tasteless and odourless and acidic in reaction. It is a complex mixture of enzymes and specific toxins and is a good digestive juice. It is fatal only when mixed in blood. It is precipitated in reagents such as silver nitrate and potassium permanganate. It can be dried

and kept indefinitely retaining its poisonous properties. It can be dissolved in water, salt solutions or glycerine.

Symptoms of Snake bite

The Venom of different snakes has its own characteristic effect. Degree of virulence differs not only in different snakes but in the same snake under different circumstances. The bitten person may die or recover depending upon the amount injected and its virulence. It is customary to regard two categories of snake venoms—**Neurotoxic** and **Haemotoxic**. Neurotoxins are typical of elapsids (Cobra and Krait) and sea snakes. The cause of death by paralysis of respiratory muscles and asphyxiation. Haemotoxins are typical of vipers. They cause tissue destruction and widespread haemorrhage. The effects of venom or symptoms of snake bite in case of 3 most common poisonous snakes of India are as follows :

Cobra bite—Poison of Cobra is neurotoxin attacking nerve centres and causing paralysis of muscles especially those of respiratory muscles. Symptoms include piercing pain and burning sensation ending in numbness of bitten part which turn bluish. Person suffers from giddiness, weakness in legs, high pulse rate, speechlessness, drooping of saliva and eyelids, contraction of pupils, vomiting and laboured breathing. Death results within few hours due to failure of respiration (asphyxia) or heart failure. Late Prof. K. N. Bahl described cobra bite poisoning by the word CO—BRA, indicating that spinal cord (CO) and brain (BRA) are affected. Coagulation of blood (COB) is reduced (R), so that wound bleeds for hours and death occurs by asphyxia (A).

Krait bite—Kraits are most dangerously poisonous snakes because their bite injects a very large quantity of poison. Symptoms are very similar to those of cobra bite, except that the victim complains of unbearable abdominal pain due to internal haemorrhage. Destruction of RBCs (haemolysis) and paralysis of trunk and limbs occur followed by death within 6 to 24 hours.

Viper bite—Venom of viper is mainly haemotoxic affecting the circulatory and nervous system more severely. Symptoms include local swelling and discolouration of bitten part with acute burning pain. A red fluid oozes out from wound due to massive tissue destruction (necrosis) which frequently necessitates amputation. Pupils dilate, pulse rate increases profuse vomiting occurs and victim loses conciousness. Death may result due to paralysis of vaso-motor centres and exhaustion from profuse bleeding.

Antivenom

Antivenom (Antivenin) is serum that contains antitoxin for snake venom. The best cure for snake bite is an antivenom serum or antivenin which is injected into the body of the victim to counteract snake venom. Different antivenins are required against different snakes due to differences in the qualities of their venoms. An antivenin is prepared by injecting a horse with gradually increasing doses of a snake venom until the horse becomes fully immunized to any amount of venom injected. The blood serum of these immunized horses is collected and preserved. This is antivenom serum or antivenin which has developed sufficient antibodies to neutralize the effect of that particular snake venom. Most of the antivenin is prepared in Haffkine Institute, Bombay, and Central Research Institute, Kasauli (Simla Hills).

Distinction between poisonous and non-poisonous snakes

Most of the Indian snakes are non-poisonous and harmless creatures. The poisonous snakes are distinguished from non-poisonous snakes on the basis of the shape of their tails and size and arrangement of scales and shields on their body. A simple workable key of identification of Indian poisonous and non-poisonous snake is given in the following table :

Key to Identify Poisonous from Non-Poisonous Snakes of India

Structures	Characters	Nature	Snakes
1. Tail	(a) Tail laterally compressed, oar-like	Poisonous	Sea snakes *Hydrophis, Enhydrina*
	(b) Tail cylindrical, tapering.	Poisonous or nonpoisonous Examine further	Land snakes
2. Belly scales or ventrals	(a) Belly scales small, continuous with dorsals	Non-poisonous	Pythons
	(b) Ventrals not fully broad to cover belly	Non-poisonous	
	(c) Ventrals broad, fully covering belly	Examine further	
3. Head scales, loreal pit, subcaudals	(a) Head scales small. Head triangular. No loreal pit	Poisonous	Pitless vipers
	(i) Subcaudals double	Poisonous	*Vipera russelli*
	(ii) Subcaudals single	Poisonous	*Echis carinata*
	(b) Head scales small. A loreal pit present between nostril and eye	Poisonous	Pit vipers *Lachesis, Ancistrodon*
	(c) Head with large shields. No loreal pit.	Examine further	
4. Vertebrals, 4th infralabial, 3rd supralabial	(a) Vertebrals enlarged, hexagonal 4th infra-labial largest	Poisonous	Krait, *Bungarus*
	(b) Vertebrals not enlarged. 3rd supra-labial touches eye and nostril	Poisonous	
	(i) Neck with a hood and spectacle mark	Poisonous	Cobra, *Naja*
	(ii) Hood absent. Coral spots on belly	Poisonous	Coral snakes, *Callophis*
	(c) No such characters	Nonpoisonous	

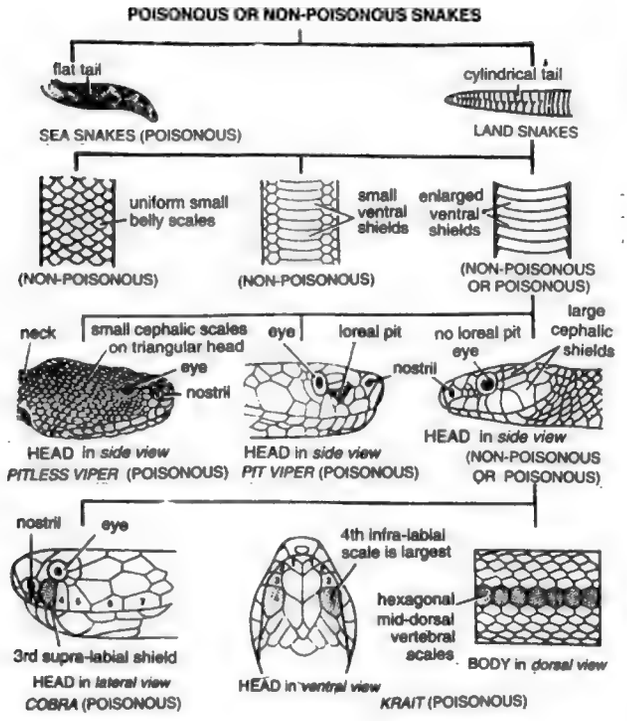


Fig. : Diagrams for identification of poisonous and non-poisonous snakes.

Significant Facts of Snakes

- Study of snakes is known as Ophiology.
- Eyelids are absent in snakes.
- Fangs are poisonous teeth, which are modified maxillary teeth.
- Poison glands are modified salivary glands.
- Tympanum and middle ear is absent in snakes.
- Hydrophis and viper dryophis snakes are viviparous.
- Cobra and krait venom is neurotoxic.
- Viper venom is haemotoxic.
- Antivenin is used for the treatment snake bite.
- Hoffkin's Institute, Bombay is well known for antivenin production.
- Snakes can perceive sound waves passing through solid terrain of earth only.
- Jacobson's organs are the olfactory organs of snakes.
- Venom is proteinous and acidic in nature.
- Snakes can digest hairs, feathers and horns.

OBJECTIVE QUESTIONS

1. Antivenom injections for snake bite are prepared at—
   (A) I. A. R. I. New Delhi
   (B) N. D. R. I. Lucknow
   (C) N. D. R. I. Karnal
   (D) Haffkine's Research Institute, Bombay
2. Laterally compressed tail is present in—
   (A) Cobra (B) Krait
   (C) Hydrophis (D) Boa
3. Which of the following snake has vestigial pelvic girdle ?
   (A) *Bungarus* (B) *Eryx*
   (C) *Natrix* (D) *Python*
4. Which one of the following is a marine snakes ?
   (A) Bungarus (B) Natrix
   (C) Hydrophis (D) Eryx
5. Head is covered by scales in—
   (A) Cobra
   (B) Krait
   (C) Viper
   (D) All the above
6. Which one of the following is non-poisonous snake ?
   (A) Sea snake
   (B) Bungarus
   (C) Viper
   (D) Python
7. In poisonous snakes the fangs are developed on—
   (A) Mandibles (B) Maxilla
   (C) Quadrate (D) Squamosal
8. Krait (Bungarus) can be differentiated from other snakes by its—
   (A) Shields on head
   (B) Size
   (C) Colouration of body
   (D) Enlarged hexagonal vertebral scales
9. The largest Indian poisonous snake is—
   (A) Krait
   (B) Russell's viper
   (C) King Cobra
   (D) Python
10. The poisonous glands of a poisonous snakes are modified—
    (A) Buccal glands
    (B) Salivary glands
    (C) Palatine glands
    (D) Lacrimal glands
11. If the fang of a poisonous snake is pulled out or broken off, they are—
    (A) Never replaced
    (B) Replaced by another fang
    (C) Replaced by teeth but not fang
    (D) Lost for ever
12. In snakes—
    (A) Eyelids are absent
    (B) Immovable eyelids present
    (C) Movable eyelids present
    (D) None of the above is correct
13. Olfactory organ of snake is—
    (A) Jacobson's organ
    (B) Johnston's organ
    (C) Organ of Bojanus
    (D) None of the above
14. Fangs of snakes are—
    (A) Monophyodont
    (B) Diphyodont
    (C) Triphyodont
    (D) Polyphyodont
15. Which of the following snake is viviparous ?
    (A) Python
    (B) King Cobra
    (C) Viper dryophis
    (D) Krait

ANSWERS

1. (D) 2. (C) 3. (D) 4. (C) 5. (C)
6. (D) 7. (B) 8. (D) 9. (C) 10. (B)
11. (B) 12. (A) 13. (A) 14. (D) 15. (C)

●●●

ZOOLOGY

1. Proteinous cells in cartilage and collagen matrix are—
   (A) Chondrocytes
   (B) Choanocytes
   (C) Amoebocytes
   (D) Lymphocytes
2. Mammals generate much heat metabolically in a process called—
   (A) Thermogenesis
   (B) Endogenesis
   (C) Ketogenesis
   (D) All the above
3. The excretory unit of the vertebrate kidney is—
   (A) Nephron
   (B) Nephrocytes
   (C) Nephridium
   (D) All the above
4. HCl is secreted from—
   (A) Kuffer cells
   (B) Mast cells
   (C) Choanocytes
   (D) Oxyntic cells
5. A camel show resistance against heat of a desert by—
   (A) Storing water in its hump
   (B) Shunting blood into its hump
   (C) Allowing its body temperature to drop at night
   (D) None of the above
6. Continental drift explains the occurrence of—
   (A) Mass extinctions
   (B) Distribution of fossils on earth
   (C) Geological upheavals like earthquake
   (D) All the above are correct
7. Body cavity of Hydra is—
   (A) Coelenteron
   (B) Haemocoel
   (C) Archenteron
   (D) All of these
8. In house fly pseudotracheae are formed by—
   (A) Rostrum
   (B) Haustellum
   (C) Basiproboscis
   (D) Labella
9. Role of mutations in evolution is—
   (A) Reproductive isolation
   (B) Genetic variation
   (C) Genetic drift
   (D) None of the above
10. Sexual dimorphism is found in—
    (A) Ascaris (B) Amoeba
    (C) Pheretima (D) All of these
11. Sertoli cells are involved in—
    (A) Nutrition of developing sperms
    (B) Excretion
    (C) Respiration
    (D) All of these
12. The production of ATP from phosphate and ADP in aerobic respiration is called—
    (A) Oxidative phosphorylation
    (B) Deoxygenation
    (C) Oxidative polymerisation
    (D) Oxidative epimerisation
13. An enzyme that catalyses the partial hydrolysis of proteins to polypeptides is—
    (A) Renin (B) Pepsin
    (C) Trypsin (D) Lipase
14. An enzyme that converts the soluble protein fibrinogen into the fibrous fibrin during blood clotting is—
    (A) Thyrotrophin
    (B) Thrombin
    (C) Collegenase
    (D) Oxygenase
15. Which of the following scientist discovered jumping genes ?
    (A) Hugo de Vries
    (B) Barbara McClintock
    (C) Keith Porter
    (D) Milton Rand
16. Which of the following gland secretes life saving hormone ?
    (A) Adrenals (B) Thymus
    (C) Thyroid (D) Pineal
17. Hypocalcemia is caused by under secration of—
    (A) Parathormone
    (B) Testosterone
    (C) Thyroxine
    (D) Glucagon
18. Protonephridial system is found in—
    (A) Fasciola (B) Earthworm
    (C) Ascaris (D) Nereis
19. The study of parasites and their relationships to one another and their hosts is called—
    (A) Xenology (B) Teratology
    (C) Phenology (D) Rheology
20. Which one of the following is the key intermediate compound linking glycolysis to the Krebs cycle ?
    (A) NADH (B) ATP
    (C) Malic acid (D) Acetyl CoA
21. The RNA that picks up specific amino acid pool in the cytoplasm to ribosome during protein synthesis is called—
    (A) *m*-RNA (B) *t*-RNA
    (C) *r*-RNA (D) RNA
22. Centromere is a part of—
    (A) Ribosomes
    (B) Mitochondria
    (C) Chromosome
    (D) Endoplasmic reticulum
23. Which is most stable ecosystem ?
    (A) Forest (B) Mountain
    (C) Desert (D) Ocean
24. Infective stage of Plasmodium is—
    (A) Trophozoite
    (B) Merozoite
    (C) Sporozoite
    (D) Metacryptozoite
25. Which of the following harmone is/are secreted by pituitary gland ?
    (A) Somatotrophic hormone
    (B) Follicle stimulating hormone
    (C) Growth hormone
    (D) All the above

26. Demonstration of first conditioned reflax was made by—
(A) Karl Von Frisch
(B) Robert Brown
(C) Pavlov
(D) Pasteur

27. Acetylcholine is responsible for transmission of nerve impulses through—
(A) Cytons (B) Dendrites
(C) Axons (D) Synopses

28. Who discovered that blood transfusion is successful only when blood of the donor resembles that of the recipient—
(A) Karl Marx
(B) Neel and Beet
(C) Karl Landsteiner
(D) Mukusick

29. Sebaceous glands are—
(A) Apourine (B) Holocrine
(C) Mesocrine (D) Endocrine

30. A dicentric chromatid at meiotic anaphase I would result in the formation of—
(A) Supernumerary chromosomes
(B) Chromatin bridge
(C) Ring chromosomes
(D) V-shaped chromosomes

31. Which one is a myeloid tissue ?
(A) Blood
(B) Lymph
(C) Bone marrow
(D) Spleen

32. A neopallium is found in the brain of—
(A) Mammals (B) Birds
(C) Fishes (D) Frogs

33. Asthama is a disease of—
(A) Blood
(B) Bronchial tubes
(C) Muscles
(D) Kidney

34. Small pox vaccine was invented by—
(A) Edward Jenner
(B) Reukart
(C) Muller
(D) Rockstein

35. The vascular pigmented middle layer of the eyeball is called—
(A) Sclera (B) Cochlea
(C) Choroid (D) Retina

36. The introduction of foreign DNA into vector DNA to produce *r*-DNA requires which enzyme ?
(A) Reverse transcriptase
(B) Restriction enzyme
(C) DNA ligase
(D) Both (B) and (C)

37. The fluctuation of allele frequencies in a small population entirely due to chance is known as—
(A) Genetic drift (B) Speciation
(C) Fitness (D) Altruism

38. Translation of proteins require—
(A) *m*-RNA
(B) Ribosomal RNA
(C) *t*-RNA
(D) All of the above

39. Tube feet are locomotory organs of—
(A) Starfish (B) Jelly fish
(C) Crop fish (D) Silver fish

40. Number of cervical vertebrae found in mammals are—
(A) 5 (B) 6
(C) 7 (D) 11

41. The typhlosole in earthworm is related with—
(A) Excretion
(B) Absorption
(C) Respiration
(D) Reproduction

42. The conversion of absorbed food material into protoplasm, is termed as—
(A) Digestion
(B) Absorption
(C) Assimilation
(D) Defaecation

43. The pseudopodia of Amoeba are locomotory organelleles. These are tipped by—
(A) Pellide (B) Cuticle
(C) Hyaline cap (D) Plasmasol

44. Bladderworm is the larva of—
(A) Liver fluke
(B) Planaria
(C) Tapeworm
(D) Roundworm

45. Genome is—
(A) Haploid set of chromosomes
(B) Two sets of centromere
(C) Two generative nuclie
(D) Diploid and tetraploid chromosomes

46. The body cavity of coelenterates is—
(A) Coelenteron
(B) Coelom
(C) Pseudo coelom
(D) Haemocoelom

47. A nitrogenous base found in DNA and RNA. It is also a constituent of certain coenzymes *e.g.* NAD and FAD—
(A) Cytosine (B) Adenine
(C) Guanine (D) Uracil

48. Precipitin test is performed to detect—
(A) Fats
(B) Carbohydrates
(C) Lipids
(D) Specific antigens

49. The osmoregulatory tissue in all animals is—
(A) Epithelial (B) Connective
(C) Nervous (D) Muscle

50. The term genotype was proposed by—
(A) T.H.Morgan (B) Boveri
(C) Sutton (D) Johannson

ANSWERS

1. (A) 2. (A) 3. (A) 4. (D) 5. (C)
6. (D) 7. (A) 8. (D) 9. (B) 10. (A)
11. (A) 12. (A) 13. (B) 14. (B) 15. (B)
16. (A) 17. (A) 18. (A) 19. (A) 20. (D)
21. (B) 22. (C) 23. (D) 24. (C) 25. (D)
26. (C) 27. (D) 28. (C) 29. (B) 30. (B)
31. (C) 32. (A) 33. (B) 34. (A) 35. (C)
36. (D) 37. (A) 38. (D) 39. (A) 40. (C)
41. (B) 42. (C) 43. (C) 44. (C) 45. (A)
46. (A) 47. (B) 48. (D) 49. (A) 50. (D)

HINTS

3. Nephron is the structural and functional unit of the kidney, consisting of a renal corpuscle (a glomerulus) and a uriniferous tubule. Water, salts, nitrogenous wastes etc. are filtered across the walls of glomerulus and collected by the Bowman's capsule.

(Continued on Page 99)

ZOOLOGY

1. Antlers are the horns of—
   (A) Goat (B) Rhino
   (C) Ox (D) Deer
2. Proteins which are tightly associated with DNA in the chromatin, are—
   (A) Spectrins (B) Ankyrin
   (C) Histones (D) Elastin
3. Anticoagulant Heparin is secreted by—
   (A) Mast cells
   (B) Fibroblasts
   (C) Plasmocytes
   (D) Adipocytes
4. Cross bridges, which connect the molecules of a fibril during muscle contraction, are made of—
   (A) Actin
   (B) Collagen
   (C) Myosin
   (D) Creatine phosphate
5. The phenomenon of 'metachrosis' is found in—
   (A) Mammals
   (B) Amphibia
   (C) Birds
   (D) All of the above
6. LH and FSH hormones together are called—
   (A) Emergency hormone
   (B) Gonadotrophic hormone
   (C) Neuro hormones
   (D) Outstress hormone
7. Which nerve innervates the muscles of tounge, jaws and hyoid ?
   (A) Vagus
   (B) Hypoglossal
   (C) Facial
   (D) Glossopharyngeal
8. Electron transport systems—
   (A) Are found both in mitochondria and chloroplasts
   (B) Release energy as electrons are transferred
   (C) Are involved in the poduction of ATP
   (D) All of these are correct
9. Crossing over occurs between—
   (A) Sister chromatids of same chromosomes
   (B) Two different bivalents
   (C) Non sister chromatids of a bivalent
   (D) Two daughter nuclie
10. Restriction fragment length polymorphisms (RFLPs)—
    (A) Identify individuals genetically
    (B) Is the basis for DNA fingerprints
    (C) Can be subjected to gel electrophoresis
    (D) All of these are correct
11. The osmoregulatory tissue in all animals is—
    (A) Epithelial (B) Connective
    (C) Nervous (D) Muscular
12. Hypotension or chronic blood pressure may develop from—
    (A) Not enough blood proteins due to low-protein diet
    (B) High-fat, high cholesterol diet
    (C) Too much emotional stress
    (D) Too much caffeine or nicotine
13. The theory behind the use of lymphokines in cancer therapy is that—
    (A) If cancer develops, the immune system has been ineffective
    (B) Lymphokines stimulate the immune system
    (C) Cancer cells bear antigens that should be recognizable by cytotoxic T-cells.
    (D) All of these are correct
14. Which vitamin helps in formation of Red blood cells ?
    (A) Vitamin B_{12} (B) Vitamin B_6
    (C) Vitamin A (D) Vitamin C
15. The hepatic portal vein is located between the—
    (A) Hepatic portal vein and the vena cava
    (B) Mouth and the stomach
    (C) Pancreas and the small intestine
    (D) Small intestine and the liver
16. Carbon dioxide is carried in the plasma—
    (A) In combination with methaemoglobin
    (B) As the bicarbonate ion
    (C) Combined with carbonic anhydrase
    (D) All of these are correct
17. ADH causes individuals to excrete—
    (A) Sugars
    (B) Less water
    (C) More water
    (D) Both A and C are correct
18. A spinal nerve carries impulses—
    (A) To the CNS
    (B) Away from the CNS
    (C) Both to and away from the ANS
    (D) Only inside the CNS
19. A virion is a—
    (A) Virus
    (B) Viral ribosome
    (C) Viral lysosome
    (D) Viral gene
20. Aldosterone causes the—
    (A) Kidneys to excreto potassium ions
    (B) Kidneys to reabsorb sodium ions
    (C) Blood volume restoration
    (D) All of these are correct
21. Down syndrome—
    (A) Is always caused by nondisjunction of chromosome-21
    (B) Shows no overt abnormalities
    (C) Is more often seen in children of mothers attaining the age of forty and above
    (D) Both A and C are correct
22. When a population is small, there is a greater chance of—
    (A) Gene flow
    (B) Genetic drift

(C) Natural selection
(D) Mutations occurring

23. When two or more nonallelic gene pairs affect the same characters in the same way, this is called—
(A) Polygenic inheritance
(B) Pleiotropy
(C) Total penetrance
(D) Additive expressivity

24. Which of these systems contribute to homeostasis ?
(A) Digestive and excretory system
(B) Respiratory and Nervous system
(C) Nervous and Endocrine system
(D) All of these are correct

25. Morphogenesis is best associated with—
(A) Overall growth
(B) Induction of one tissue by one another
(C) Genetic mutations
(D) All of these are correct

26. Which one of these does not pertain to B-cells ?
(A) Have passed through the thymus
(B) Specific receptors
(C) Antibody-mediated antibody
(D) Synthesize and liberate antibodies

27. Pressure filtrate is associated with the—
(A) Glomerular capsule
(B) Distal convoluted tubule
(C) Collecting duct
(D) All of these are correct

28. The function of cerebellum is—
(A) Muscle coordination
(B) Balance coordination
(C) Transmitting impulses
(D) All of the above

29. Antibodies are synthesized by—
(A) B lymphocytes
(B) Phagocytes
(C) Helper T lymphocytes
(D) Killer T lymphocytes

30. Substrate-level phosphorylation takes place in—
(A) Glycolysis
(B) Krebs cycle
(C) Electron transport system
(D) Both A and B

31. Systole refers to the contraction of the—
(A) Major arteries
(B) SA node
(C) Atria and ventricle
(D) All of these are correct

32. The blood cortisol level controls the secretion of—
(A) Releasing hormone from the hypothalamus.
(B) Adreno-cortico tropic hormone (ACTH) from the anterior pituitary.
(C) Cortisol from the adrenal cortex.
(D) All of these are correct.

33. When the action potential begins sodium gate opening and allowing Na^+ to cross the membrane, the polarity changes to—
(A) Negative outside and positive inside
(B) Positive outside and negative inside
(C) There is no difference in charge between outside and inside
(D) Any of these could be correct

34. Excretion of a hypertonic urine in humans is associated with the—
(A) Glomerular capsule
(B) Proximal convoluted tubule
(C) Loop of the nephron
(D) Distal convoluted tubule

35. Which two of these chromosomal mutations are most likely to occur when homologous chromosomes are undergoing synapsis?
(A) Inversion and translocation
(B) Deletion and duplication
(C) Deletion and inversion
(D) Duplication and translocation

36. The transition reaction—
(A) Connects glycolysis to the krebs cycle
(B) Gives off CO_2
(C) Utilizes NAD^+
(D) All of these are correct

37. Fatty acids are broken down to—
(A) Pyruvate molecules, which take electrons to the electron transport system
(B) Acetyl groups, which enter the krebs cycle
(C) Amino acids, which excrete ammonia
(D) All of these are correct

38. In a DNA molecule, the—
(A) Bases are covalently bonded to the sugars
(B) Sugars are covalently bonded to the phosphates
(C) Bases are hydrogen-bonded to one another
(D) All of these are correct

39. RNA processing is—
(A) The same as transcription
(B) An event that occurs after RNA is transcribed
(C) The rejection of old, worn-out RNA
(D) Both B and C are correct.

40. If the sequences of bases in DNA is TAGC, then the sequence of bases in RNA will be—
(A) ATCG
(B) TAGC
(C) AUCG
(D) Both A and B are correct

41. Which stage of Mitotic cell division is longest ?
(A) Anaphase (B) Telophase
(C) Prophase (D) Metaphase

42. Which one of the following is immortal ?
(A) Germ cell
(B) Somatic cell
(C) Pituitary cell
(D) Glomerular cell

43. Hermit crab and sea anemone association is called—
(A) Commensalism
(B) Symbiosis
(C) Mutualism
(D) None of these

44. The process by which the developing notochord causes dorsal ectoderm above it to form a neural plate is known as—
(A) Induction
(B) Invagination
(C) Differentiation
(D) Morphogenesis

45. Transformation of a non-motile, unspecialized spermatid into a

motile and specialized mature sperm is called—

(A) Spermatogenesis
(B) Spermatogonia
(C) Spermiogenesis
(D) Spermatocyte

46. Segments of DNA, which are capable of moving into and out of a chromosome are called—
(A) Transposons
(B) Template
(C) Replicon
(D) Muton

47. The ovulation is started with the stimulation of—
(A) Luteinizing hormone
(B) FSH
(C) Estrogen
(D) All of the above

48. Spermatogenesis is stimulated by—
(A) Estrogen
(B) Progesterone
(C) Gonadotropins
(D) All of the above

49. Which one of the following is first larval stage involved in the life cycle of *Fasciola hepatica*?
(A) Miracidium
(B) Planula
(C) Redia
(D) Trochophore

50. A nephridium of an earthworm drains materials directly from the—
(A) Gut (B) Coelom
(C) Blood (D) Lymph

ANSWERS

1. (D) 2. (C) 3. (A) 4. (C) 5. (B)
6. (B) 7. (B) 8. (D) 9. (C) 10. (D)
11. (A) 12. (A) 13. (D) 14. (A) 15. (D)
16. (B) 17. (B) 18. (C) 19. (A) 20. (D)
21. (D) 22. (B) 23. (A) 24. (D) 25. (B)
26. (A) 27. (A) 28. (D) 29. (A) 30. (D)
31. (C) 32. (D) 33. (A) 34. (C) 35. (B)
36. (D) 37. (B) 38. (D) 39. (B) 40. (C)
41. (C) 42. (A) 43. (A) 44. (A) 45. (C)
46. (A) 47. (D) 48. (C) 49. (A) 50. (B)

HINTS

2. Histones are basic proteins which package the eukaryotic DNA. DNA and histones comprise chromatin, forming the bulk of eukaryotic chromosome.

21. Down syndrome is congenital disorder of people caused by trisomy of chromosome 21. (often by non-disjunction). Characterized by mental retardation, mongoloid facial features, simian palm and reduced life expectancy. It is more often seen in children of mothers attain the age of forty and above.

36. In transition reaction molecule has undergone a partial chemical reaction in which CO_2 is given off and NAD^+ is utilized. Such type of reactions connect glycolysis to the krebs cycle.

46. Transposon is a DNA segment which can move from one position in the genome to other.

●●●

(Continued from Page 96)

4. The mucosa of stomach is highly folded and the single layered mucous membrane of the infoldings forms tubular and often branched gastric glands in the lamina propria. Each gland has three types of secretory cells, *i.e.*, neck cells secreting mucus, oxyntic cells secreting HCl and zymogen cells secreting pepsinogen pro-enzyme.

11. Sertoli cells are large pillar like cells located in the epithelium of the vertebrate testis, which nourish developing spermatozoa.

12. The production of ATP from phosphate and ADP in aerobic respiration. Oxidative phosphorylation occurs in mitochondria, the energy being provided by steps in the electron transport chain.

13. It is secreted by the gastric glands of stomach in an inactive form, pepsinogen and is activated by hydrogen ions. At pH value of 4·6 and less pepsin activates pepsinogen *e.g.*, it is autocatalytic. Pepsin initiates the digestion of proteins, splitting them into smaller fragments.

15. Barbara McClintock proposed the theory of jumping genes or transposable elements which can transfer their protein in the gene from one place to another.

16. Adrenal cortex secretes cortisol which serve to maintain the body in living condition and recoup it from the severe after effects of stress reactions. Thus on increased output of cortisol is life saving in shock conditions.

17. When there is under secretion of parathormone, the lend of calcium in ECF falls (hypocalcemia) and that of phosphate rises. Such a condition is responsible for neuromuscular hyperexcitability.

20. Acetyl CoA produced in glycolysis enters in Kreb's cycle through various steps in mitochondria as a result of different reactions, taking place in a cyclic manner, the complete oxidation of acetyl CoA-takes place.

22. Centromere is the region of the chromosome that becomes attached to the nuclear spindle during mitosis and meiosis. It does not stain with basic dyes. It is also called primary constriction.

31. Red bone marrow attached to argyrophil fibres which form wide meshes containing scattered fat cells, erythroblasts, myelocytes, and mature myeloid elements.

40. Cervical vertebra pertain to neck region in mammals. In mammals these are 7 in number.

41. Typholosole helps in absorption. It increases the absorptive area of intestine.

47. A nitrogenous base found in DNA and RNA. It is also a constituent of certain enzymes *e.g.*, NAD and FAD and when combined with the sugar ribose it forms nucleoside adenosine found in AMP, ADP and ATP.

50. The term genotype was proposed by Johannson (1909) for heredity or genetic constitution of an individual.

●●●

Best Fifteen Questions

ZOOLOGY

1. The light producing by fireflies, is the result of a light producing reaction involving luciferin and ATP and is catalyzed by enzyme—
   (A) Luciferase
   (B) Protein Kinase
   (C) Collagenase
   (D) Trypsin
2. Stomach mucosa cells release the inactive enzyme—
   (A) Pepsinogen
   (B) Renin
   (C) Gastrin
   (D) All the above
3. The energy rich hydrogen atoms are transported to the electron system by a carrier molecule known as—
   (A) CTP (B) NAD
   (C) ATP (D) cAMP
4. The total number of CO_2 molecules released from the Krebs cycle—
   (A) 4 (B) 2
   (C) 8 (D) 10
5. Which one of the following is not a communicable disease ?
   (A) Tuberculosis
   (B) Influenza
   (C) Botulism
   (D) Common cold
6. Antibodies differ principally in their—
   (A) Type of heavy protein chain
   (B) Disulphide bonds
   (C) Both A and B
   (D) None of the above
7. Nervous stimulation of muscles—
   (A) Occurs at neuromuscular junctions
   (B) Results in an action potential
   (C) Causes calcium to be released from storage sacs
   (D) All of these are correct
8. Diabetes mellitus is associated with—
   (A) Too much insulin in the blood
   (B) Too high a blood glucose level
   (C) Blood that is too dilute
   (D) All of these are correct
9. Retinal is—
   (A) Sensitive to light energy
   (B) A part of rhodopsin
   (C) Found in both rods and cones
   (D) All of these are correct
10. ATP synthase complex is found in—
    (A) Mitochondrial matrix
    (B) Cristae of mitochondria
    (C) Cytoplasm
    (D) Endoplasmic reticulum
11. Gene cloning is achieved when a host cell takes up—
    (A) The recombined plasmid
    (B) Plasmid reproduces daughter nuclie
    (C) Carry recombined gene
    (D) All the above
12. RNA retroviruses have a special enzyme that—
    (A) Disintegrates host DNA
    (B) Polymerizes host DNA
    (C) Transcribes viral RNA to cDNA
    (D) Translates host DNA
13. Which of the following molecule initiates nerve impulses, resulting in the sensation of pain, and stimulates most cells to release histamine ?
    (A) Erythropoietin
    (B) Bradykinin
    (C) Interferon
    (D) Lymphokines
14. Which one of these is **not** a function of the liver in adults ?
    (A) Produce bile
    (B) Store glucose
    (C) Produce urea
    (D) Make red blood cells
15. An animal must have some way of moving air or water across its gas-exchange surfaces, a process known as—
    (A) Countercurrent exchange
    (B) Ventilation
    (C) Facilitated diffusion
    (D) Active respiration

ANSWERS WITH HINTS

1. (A) 2. (A) 3. (B) 4. (A) 5. (C)
6. (A) 7. (D) 8. (B) 9. (D) 10. (B)
11. (D) 12. (C) 13. (B) 14. (D) 15. (B)

3. The energy-rich hydrogen atoms are transported to the electron transport system by a carrier molecule known as NAD (Nicotinamide adenine dinucleotide). As a result, NAD changes to NADH.
4. During the krebs cycle, the C_2 acetyl group is oxidized to two molecules of CO_2. Because two acetyl groups are utilized so the total CO_2 molecules synthesized are four in number.
6. Five major classes differ principally in their type of heavy chain, and the degree to which the molecule is a polymer of immunoglobulin 'monomers'. Each immunoglobulin unit comprises two identical H (heavy) and two identical L (light) polypeptide chains forming mirror images of each other and joined by a flexible hinge region involving disulphide bridges.
10. ATP synthase system complex is found in cristae of mitochondria which synthesize ATP by an ATP synthase. ATP leaves the matrix by way of a protein channel.

●●●

THE BOUNDARY AROUND THE PLANT CELL

—Dipanjan Ghosh

Plant cells are characterised by the presence of a non-living envelope outside the cell membrane called the **cell wall**. This boundary is very much rigid and thick which ensures the tolerance of the turgor pressure due to absorption of water by the cell, and is taken as an outstanding point of difference between plant and animal cells.

Structure of the Cell Wall :

Cell wall consists of three distinct layers. These are :

(i) Middle lamella or intercellular substance

(ii) Primary wall

(iii) Secondary wall

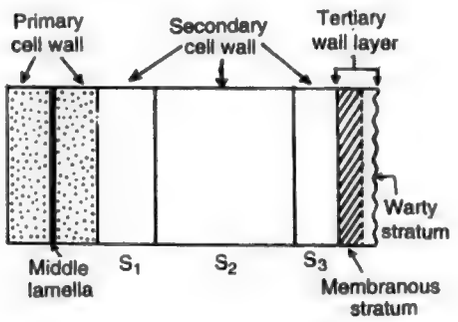


Fig. : Different layers of plant cell-wall.

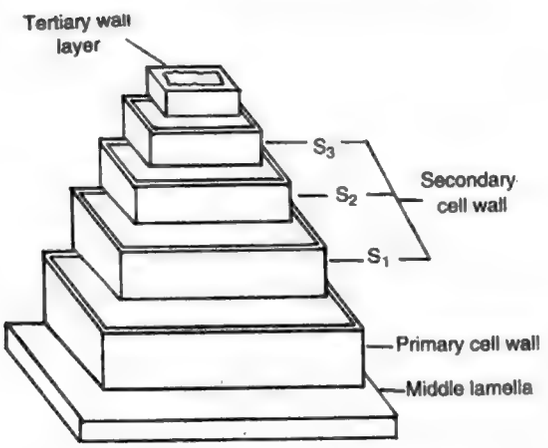


Fig. : 3-D Diagram of Cell Wall.

Middle Lamella—It is the cementing material that holds the individual cells together to form tissue. Middle lamella is located in between two primary walls of adjacent cells.

Primary Wall—It is the first true wall that develops on the new cell. In case of parenchymatous cell it is the only cell wall.

Secondary Cell Wall—The wall layer located inside the primary wall is known as the secondary cell wall. It is very thick and consists of three distinct layers in fibres and tracheids :

Outermost layer = S_1

Central layer = S_2

Innermost layer = S_3

The S_2 or central layer is the thickest. The secondary cell wall in some cases show more than three layers. **Frey-Wyssling** (1976) recognised an innermost lamellate tertiary wall. This wall layer is differentiated into two strata : **membranogenous stratum** and **warty stratum**.

Chemical Nature of the Cell Wall :

From the chemical point of view the plant cell wall (including algae and higher plants) is made up of cellulose, hemicellulose, pectin, lignin, glycoprotein and different types of proteins. Cellulose is the unbranched chain of polysaccharides made up of the aggregation of roughly 10000 glucose monomer through α-1, 4-glucosidic bonds. The cellulose chains which form the crystalline region of the cell wall are associated together forming a network of cellulose strands in the cell wall. An association of about 100 cellulose chains is termed as a **micelle**, 20 micelles constitute a **microfibril**, an aggregation of 250 microfibrils is called a **fibril**.

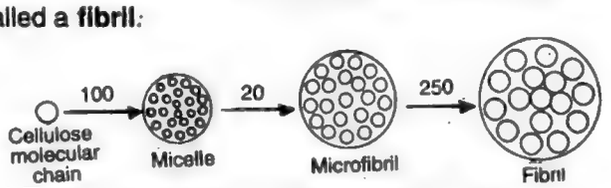


Fig. : Diagrammatic representation of the composition of fibril

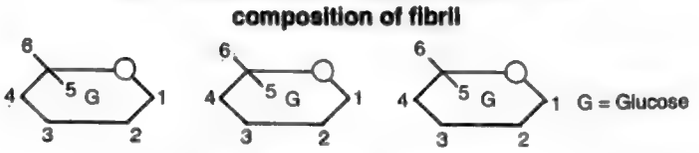


Fig. : Structure of Cellulose

This cellulose forms the microfibrillar structure at the outer boundary of plant cell. Hemicellulose is also a branched polysaccharide binds with the surface of the cellulose microfibrils forming hydrogen bond and thus giving the boundary a network system. Pectin is another branched polysaccharide and makes cross linking in the network. But pectin is negatively charged component and traps water molecules imparting the gel nature of the cell wall.

In secondary cell wall the cellulose microfibrils are arranged in a particular fashion and it is the major component of the secondary cell wall ranging from 50–80% of the wall materials. Hemicellulose is also present in small amount. But another additional phenolic residue lignin is present in the secondary wall increasing its tencil strength which is required in the cells involved in conduction and mechanical support.

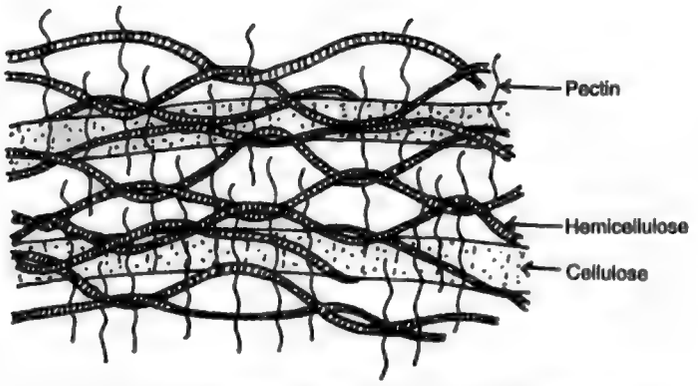


Fig. : Physico-Chemical Nature of Cell Wall (Hemicelluloses Bind to the Surface of Cellulose Microfibrils, Forming A fibrous Network that is embedded in a Gel-like matrix of pectins)

Primary cell wall remains at the extreme outside of the plant cell and it can expand with the increase in volume of the cell due to presence of cellulose, hemicellulose and pectin in equal proportions.

Primary Cell Wall	Secondary Cell Wall
1. Cellulose, hemicellulose and pectin are present in roughly equal amount.	1. Lignin is present instead of pectin.
2. Presence of cellulose is comparatively lower than the secondary wall.	2. Presence of cellulose is huge.
3. Arrangement of cellulose microfibrils are random.	3. Arrangement shows specific pattern.
4. Gel-like in nature	4. Not gel-like in nature.

The middle lamella is made up of calcium and magnesium pectate. The pectic substances are solubilized here by pectinase and chemical reagents.

The fungal cell wall is made up of **chitin** and the bacterial cell wall is made up of **muramic acid** and **glucosamine**.

Origin of the Cell Wall :

In eukaryotic plant cell, nuclear division is followed by cell wall formation. It is known as cytokinesis. During cytokinesis cell wall is formed in between two daughter cytoplasmic masses. Here at first endoplasmic reticula accumulate in the equatorial region of the cell. The endoplasmic reticulum, phragmoplast and Golgi apparatus secrete pectic substances in the form of droplets. Later these droplets cohere to form the **Cell plate**. Now the cell plate grows centrifugally forming the **middle lamella**. **Primary cell wall** is deposited on the middle lamella by the activities of the daughter cytoplasmic masses. The primary cell wall is deposited throughout the middle lamella except some areas.These areas are known as **Primary pit fields**. Through these primary pit fields, the daughter cytoplasmic masses maintain the continuity in the form of cytoplasmic strands. These are the **Plasmodesmata**.

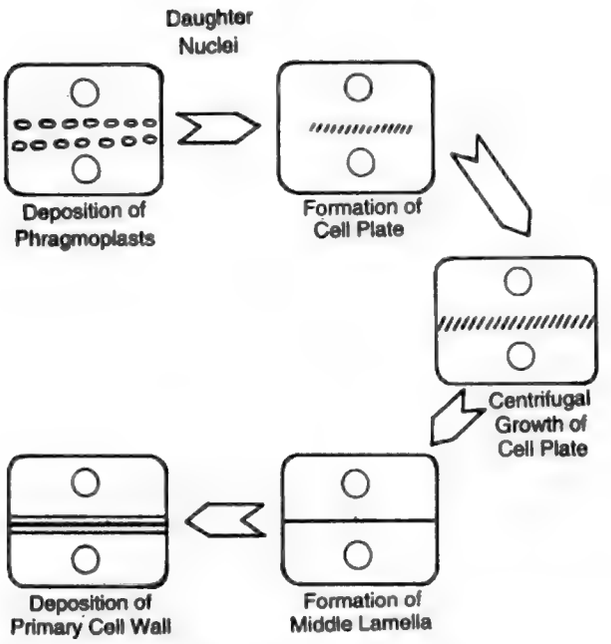


Fig. : Origin of cell wall (Diagrammatic Representation)

Growth of the Cell Wall :

Cell walls mostly show **centripetal growth** but in case of sporoderm stratification the growth is **centrifugal**. Deposition of wall materials in layers is known as **apposition**. Growth by apposition is usually centrifugal, occurring from outside. The secondary wall formation takes place when the cell ceases its growth or expansion.

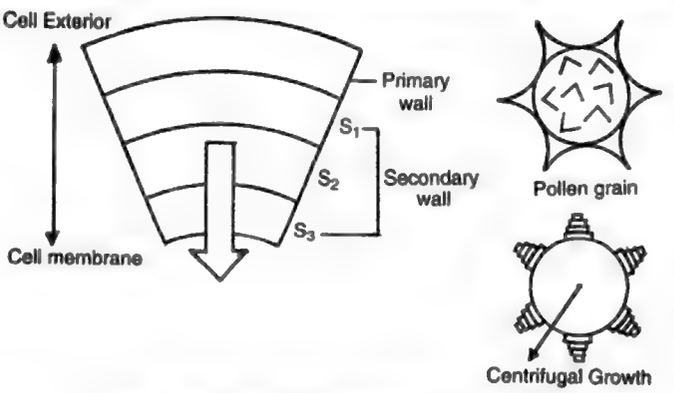
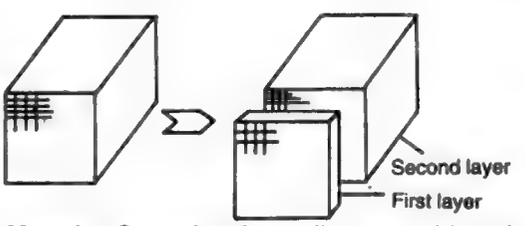


Fig. : Centripetal Development of cell Wall.

There are different views regarding the probable method of the growth of cells in surface area. Usually there are three different modes of cell growth. These are :

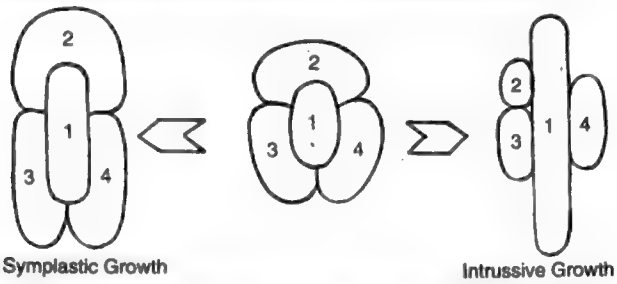
(i) **Intussusception**—In this process new wall materials are laid down between particles of the existing substance of the expanding wall in some localised areas.

(ii) **Multinet Growth**—According to this view (as proposed by **Houwink** and **Roelofsen**, 1954), loosening of the microfibrils is followed by deposition of new wall layer.



(iii) **Mosaic Growth**—According to this view (as postulated by **Frey-Wyssling** and **Stecher**, 1951), cell grows by multinet as well as intussusception.

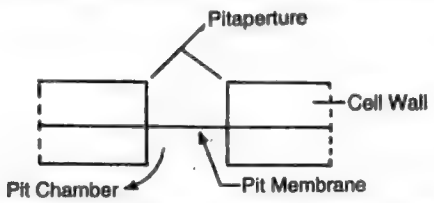
Growth of cells may show **symplastic** or **intrussive** pattern. In the former there is no new area of contact but in the latter new areas of contacts are produced.



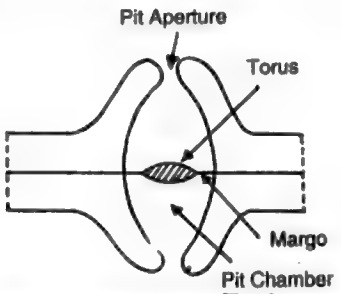
Various Modifications of the Cell Wall :

Cell walls are variously modified to perform different functions. Certain portions of the cell wall remain thin even as the secondary cell wall is formed and they, therefore, consist only of the primary cell wall. These are known as **pits**. Pits provide a channel through which adjacent cells communicate. Generally each pit has a complementary pit exactly opposite in the wall of the neighbouring cell. These two complementary pits are known as **pit pair**. Pits may be of different types. Few interesting modifications of pit are as follows :

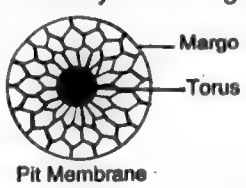
(a) **Simple Pit**—The pit in which the pit aperture as well as the pit chamber are equal in diameter is known as **simple pit**.



(b) **Bordered Pit**—The pit in which the pit chamber is over-arched by the secondary wall and the pit membrane is differentiated into **torus** and **margo** is known as **bordered pit**. The torus regulates the functional activities of the bordered pit.

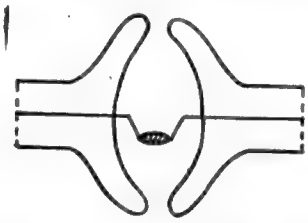


Presence of torus is characteristic in the bordered pits of gymnosperms—**Coniferales, Ginkgo** and **Gnetales**. They occur rarely in other groups of vascular plants.

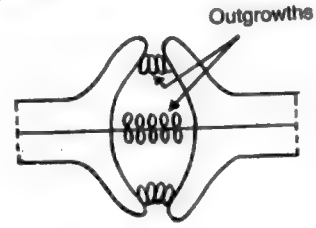


(c) **Half Bordered Pit**—A pit with half bordered and the rest half with a simple pit is known as **half bordered pit**.

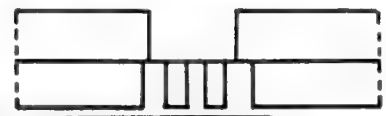
(d) **Aspirated Pit**—A non-functional pit in which the pit aperture is blocked by the torus is called an **aspirated pit**.



(e) **Vestured Pit**—A pit in which the pit chamber is blocked by minute outgrowths from the rim of the pit aperture and the pit membrane is known as **vestured pit**.

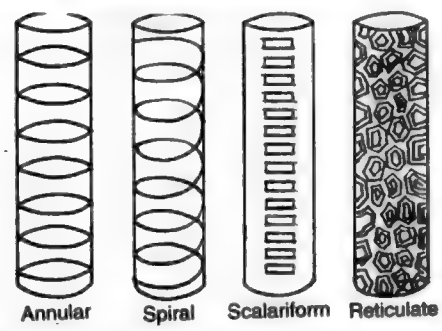


(f) **Compound/Unilateral Compound Pit**—A large pit which is complemented by two or more small pits on the adjacent side is called **Compound pit.**

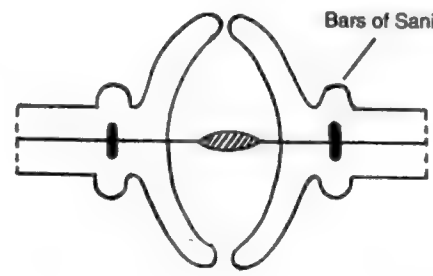


(g) **Blind Pit**—A pit without any corresponding pit on the adjacent wall is called a **blind pit**.

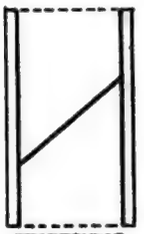
Secondary cell wall materials are deposited variously to form annular, spiral, scalariform or reticulate thickening on tracheids or trachea of vascular plants.



Tracheids of gymnospermous wood show linear or more or less circular thickening on the primary wall and middle lamella on two sides of the bordered pits. These are referred as **Crassulae** or **bars of Sanio**. Crassulae represent the borders of the primary pit fields of young cells.



A rod-shaped thickening of the cell wall traversing the lumen of the cell may be sometimes encountered is some plants. It is termed as **trabeculae**, which usually occurs in long radial series of cells.


TRABECULAE

OBJECTIVE QUESTIONS

1. Plant cells differ from animal cells in one of the following important ways—
   (A) Plant cells are not so specialized
   (B) Plant cells are comparatively bigger
   (C) All plant cells possess chlorophyll
   (D) Plant cells have a rigid cell wall
2. The function of amyloplast is to—
   (A) Store fats
   (B) Absorb water
   (C) Absorb light
   (D) Store starch
3. Cell walls of adjacent cells are connected by—
   (A) Primary cell wall
   (B) Secondary cell wall
   (C) Middle lamella
   (D) Cellulose
4. The chemical substance abundantly present in middle lamella is—
   (A) Pectin (B) Lignic
   (C) Suberin (D) Cutin
5. Continuity of cytoplasm from cell to cell is maintained through—
   (A) Middle lamella
   (B) Plasmodesmata
   (C) Vascular cambium
   (D) None of the above
6. A multinucleate cell is called—
   (A) Coenocyte
   (B) Thallus
   (C) Synaptoneme
   (D) Coenobium
7. During the formation of cell wall the secreted outermost layer of cellulose is—
   (A) Primary wall
   (B) Secondary wall
   (C) Middle lamella
   (D) All of the above
8. The plane of cell wall formation is determined by—
   (A) Endoplasmic reticulum
   (B) Nucleus
   (C) Golgi bodies
   (D) Microtubules
9. Pectin, a carbohydrate, is the polymer of—
   (A) Cutin
   (B) Mannose
   (C) Glucose
   (D) Galacturonic acid
10. The 'torus' of bordered pits is made up of—
    (A) Phospholipids
    (B) Glucose
    (C) Cutin
    (D) Suberin

ANSWERS

1. (D) 2. (D) 3. (C) 4. (A) 5. (B)
6. (A) 7. (A) 8. (D) 9. (D) 10. (D)

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(Continued from Page 57)

(C) Both (A) and (B)
(D) None of these

27. Bone ash contains—
    (A) CaO (B) $CaSO_4$
    (C) $Ca_3(PO_4)_2$ (D) $Ca(H_2PO_4)_2$
28. Which of the following salts does not impart characteristic colour to the flame ?
    (A) $MgSO_4$ (B) $CaCl_2$
    (C) $Sr(NO_3)_2$ (D) $BaCl_2$
29. Gypsum has the composition as—
    (A) $2CaSO_4 \cdot 2H_2O$
    (B) $2MgSO_4 \cdot 2H_2O$
    (C) $CaSO_4 \cdot 3H_2O$
    (D) $CaSO_4 \cdot 2H_2O$
30. Gypsum on heating to about 120°C forms the plaster of Paris. What is the composition of plaster of Paris ?
    (A) $2CaSO_4 \cdot 3H_2O$
    (B) $CaSO_4 \cdot H_2O$
    (C) $2CaSO_4 \cdot H_2O$
    (D) $CaSO_4$
31. The setting of the cement is a—
    (A) Exothermic reaction
    (B) Endothermic reaction
    (C) Neither exothermic nor endothermic
    (D) None is correct
32. Which of the following substances is not a drying and dehydrating agent ?
    (A) Silica gel
    (B) P_2O_5
    (C) Conc. H_2SO_4
    (D) Hydrated $CaCl_2$
33. If fire-work gives green flame, which one of the following radicals may be present in the fire-work ?
    (A) Na (B) K
    (C) Mg (D) Ba
34. The electrolysis of $KCl \cdot MgCl_2 \cdot 6H_2O$ gives—
    (A) Mg
    (B) K
    (C) K and Mg both
    (D) Mg and Cl_2
35. Which is the correct increasing order of solubility ?
    (A) $CaCO_3 < KHCO_3 < NaHCO_3$
    (B) $NaHCO_3 < KHCO_3 < CaCO_3$
    (C) $KHCO_3 < NaHCO_3 < CaCO_3$
    (D) $CaCO_3 < NaHCO_3 < KHCO_3$

ANSWERS

1. (C) 2. (A) 3. (D) 4. (A) 5. (D)
6. (D) 7. (D) 8. (B) 9. (C) 10. (C)
11. (D) 12. (C) 13. (B) 14. (C) 15. (D)
16. (C) 17. (C) 18. (D) 19. (A) 20. (D)
21. (C) 22. (D) 23. (D) 24. (C) 25. (C)
26. (C) 27. (C) 28. (A) 29. (D) 30. (C)
31. (A) 32. (D) 33. (D) 34. (D) 35. (D)

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SOIL EROSION AND CONSERVATION

Soil is a complex of living and non-living components. It is a medium of anchorage and sustenance for the plants. Fertility of soil is reduced by growing continuously. Soil fertility is also lost by transportation of the soil by many natural agents like water, air etc. Man is one of the major agents which causes transportation by using modern mechanical methods of agriculture. This transportation of upper fertile layer of the soil is often called as **soil erosion**. The methods used for checking the transportation or loss of soil are together known as **soil conservation**.

Soil Erosion

Top soil is about 15–20 cm deep. It takes about 500–1000 years for the formation of 2-3 cm top soil by natural methods. Generally, there remains a balance between process which form soil and those processes which cause its loss. However, this balance get disturbed if there is sudden and heavy loss due to wind, water etc.

Types of Soil Erosion

There are two types of soil erosion—

(i) **Geological or Normal Soil Erosion**—In such a type of soil erosion the top soil is removed by physical agencies of water or wind under normal conditions of physical, biological and hydrological equilibria. The rate of soil erosion is slow. In this type the rate of soil formation and soil loss are both balanced. This erosion often produces a wavy or undulating surface with alternate ridges and depressions.

(ii) **Accelerated Soil Erosion**—The removal of top soil occurs at a much faster rate as compared to the formation of new soil from below. It results in the permanent loss of fertile part of the soil. Accelerated erosion occurs due to both physical and biotic factors. Amongst the most important physical factors are excessive rainfall and drought. **Pimental** *et al* (1995) have estimated that one third of arable land of world has been lost through soil erosion during last forty years.

Major Soil Erosion Agents

Following are the types of soil erosion based on agents involved—

(1) Water erosion
(2) Wind erosion
(3) Land slides
(4) Stream bank erosion and
(5) Overgrazing and deforestation

(1) **Water Erosion**—Water erosion occurs during the melting of snow and heavy rainfall which can not be absorbed by soil. Soil cover and the slope of the area determine the degree of water erosion. In the absence of soil cover rain drops bombard the soil directly and churn up the same. This takes place by following three methods :

(a) **Sheet Erosion**—It occurs on the smooth and gentle slopes. The top soil is removed in thin layers or sheets. No conspicuous water channels are formed so that sheet erosion is not easily discernible. It is, however, most widespread and occurs in serious proportions on unprotected soils having 1-2% slope. Sheet erosion causes thinning of surface layers of soil. It gives rise to areas of light colour or **galled spots**.

(b) **Rill Erosion**—The run off water has a great cutting and carrying power. Whenever it meets loose or tilled soil and uneven area, it causes cutting of soil. The cuts initially appear in the form of finger like or groove like narrow depressions called **rills**. The rills function as narrow water channels in which flowing water picks up more speed and higher cutting power.

(c) **Gully Erosion**—Rills join to form deeper and wider channels called **gullies**. Formation of gully is assisted by the presence of natural depressions, field furrows, animals trails, wheel marks or marks of agricultural implements. Gullies are either V- or U-shaped.

(2) **Wind Erosion**—This occurs commonly in dry regions like deserts. High velocity winds carry soil particles from one place to another. This occurs by following three methods—

(a) **Suspension**—The fine soil particles, less than the size of 1 mm, get suspended in wind. They are carried as dust. The dust stroms contain these particles in large number. They are deposited several kilometres away when the wind velocity decreases.

(b) **Saltation**—It occurs in case of particles having a size of 1·0–1·5 cm. The particles are forced to roll along the ground for some distance and then suddenly kicked up into the air by the force of wind. However, because of their weight they can not remain in suspension for long. After about a height of 30 cm the particles fall back to the ground into an almost straight line. On striking the ground these particles may rebound and undergo another saltation or sink to the surface.

(c) **Surface Creep**—Large sized and heavy soil particles can not be blown into the air. These are only pushed due to great velocity of wind. This type of erosion forms **sand dunes**.

> The formation of desert is controlled by several factors. Dry weather, drying of rivers overgrazing, clean tilling, fire and falling of trees are some of the important causes of formation and spread of deserts. Thar desert of Indian subcontinent (Rajasthan, and Sind area of Pakistan) has been formed by the combination of all these factors. It has suffered at least 5 arid periods since the stone age (Legris and Meher Homji 1975). Part of the area got temporarily submerged under sea. Some of the rivers flowing through the area changed their courses or become dry.

(3) **Land Slides**—Parts of the hills become heavier due to continuous and heavy rains. These parts either fall or shade downwards due to gravitational pull.

(4) **Stream Bank or Riparian Erosion**—The flood water strike constantly against the river banks. This results in causing through the banks and new water channels are formed. The river may now change the course and water begins to flow in different directions.

(5) **Overgrazing and Deforestation**—The top soil gets removed and soil fertility decreases due to overgrazing. One of the major reasons for the formation of Rajasthan desert is said to be overgrazing.

Soil Conservation

Soil conservation is the practice of arresting and minimizing artificially accelerated soil deterioration. Its importance has grown because cultivation of soils for agricultural production, deforestation and forest cutting, grazing of natural range, and other substances of the natural cover and position of the soil have increased greatly in the last one hundred years. Soil conservation is defined as "the management of soil to prevent or reduce soil erosion and depletion by wind and water or biochemical agents."

Principles of Soil Conservation

The actual act of soil conservation is based on certain basic principles, which include the following heads—

I. Protection of soil from impact of rain drops.
II. Prevention of water from concentrating and moving down the slope in a narrow path.
III. To slow down the water movement when it flows along the slope.
IV. To grow the strips of stubble or other vegetation cover which might catch and hold the moving soil particles.
V. To encourage more water to enter the soil.
VI. Reduction in the wind velocity near the ground by growing vegetation and riding the land.
VII. To increase the size of soil particles.

Accelerated erosion due to misuse of resources of land, water and soil is today one of the most difficult and pressing problems before man. The problem has received the attention of forest ecologists, soil scientists and soil engineers only recently.

In India soil conservation is supervised by a central soil conservation board which has 9 research centres spread over the country—**Dehradun, Kota, Ootacamund, Bellary, Vasad, Agra, Chandigarh, Jodhpur** and **Chakrotta.**

Methods of Soil Conservation

Practical methods of soil conservation are grouped under biological measures and mechanical or engineering methods.

(A) Biological Methods

The biological methods of soil conservation include the following practices or methods—

Agronomic Practices—The important agricultural practices which contribute to the conservation and productivity of cultivated lands are referred to as **conservational farmings** or **advanced agronomical** methods which are given as below—

(a) **Contour Farming**—This method is practiced in the hilly regions or on the slopes. The rain water, in such areas, is absorbed in very little amount because of its quick downward movement on the slopes. If these slopy areas are ploughed up and down the slope, the heavy rainfall may cause gully development. Taking this defect in consideration, the slopy areas are ploughed and seeded against the slope *i.e.*, in circular furrows around the slopes. This process is termed as **contour farming**. The contours (circular or peripheral furrows) catch the downwardly moving water until it is absorbed in the soil. Therefore, contour farming reduces run off, saves more water for crops, reduces soil erosion and results into more yielding of crops.

(b) **Strip Cropping**—Strip cropping is an important method which employs all the advanced cultivation practices such as cover cropping, proper tillage, crop rotation, mulching and contour farming.

Strip cropping is very effective and practical means for soil conservation. It is of the following types—

(i) **Contour Strip Cropping**—It is a special kind of contour farming in which soil exposing crops are grown on the strips across the slope on the level of contour and in the following seasons soil protecting crops are sown on the strips on which soil exposing crops were grown in the previous season. This practice is useful because it checks the fast flow of run off water, increases the water infiltration in the soil and checks soil erosion.

(ii) **Field Strip Cropping**—It is a kind of farming in more or less parallel strips across fairly uniform slopes but not on the exact contour.

(iii) **Temporary or Permanent Buffer Strip Cropping**—It is a special type of contour strip cropping in which attention is paid to check the soil erosion. In such type, crop rotation practice is not applied and on the strip perennial legumes and grasses are planted on temporary or permanent basis.

(iv) **Wind Strip Cropping**—In this case tall growing plants alternating with short growing crops are sown in long straight stips right across the direction of wind regardless of contour.

(c) **Tillage Operation and Land Fallow Maintenance**—Recentely several researches support the view that in dry areas, shallow plouging gives comparatively good crop yields. Shallow ploughing removes the weeds and enables the soil to absorb water. If the land is left uncultivated and grazing animals are allowed to graze and sit over it for sometime, the soil becomes fertile.

(d) **Mulching**—Mulching means covering the soil surface by straw leaves or grasses. Mulches of various sorts check soil erosion, increase soil fertility and also minimize moisture evaporation from the top soil.

(e) **Crop Rotation—Sowing of Legumes and Mixed Cropping**—Rotation of crop is an important method for checking soil erosion and maintaining productivity of soil. After every two years crop in the same growing field should be changed. A good rotation should include a cultivated row crop, densely planted small grasses and

spreading legume. Selection of crops for rotation should be made taking into consideration the climate, soil types, soil texture, slopes, etc. Deep-rooted crops should be rotated by shallow–rooted crops. Deep-rooted crops absorb nutrients from the deeper strata of the soil. Thus the minerals of top soil remain stored for future use by shallow-rooted plants. When the deep-rooted crops die, they add humus in the soil which is store house for future plant nutrients.

Leguminous plants play active role in increasing the nitrogenous contents in the soil because of the fact that bacteria inhabiting their root nodules fix the free nitrogen of atmosphere into nitrogenous compounds such as nitrates, nitrites, ammonium salts, amino acids and proteins. The nitrogenous compounds return to the soil by way of death and decay of underground nodulated roots of these legumes.

Importance of Crop Rotation

- Controls the recurrence of weeds and disease.
- Improves crop production in a given ploughing field
- Enriches the soil and its fertility.
- Improves the soil texture.
- Improves the water holding capacity of the soil.
- The minerals of top soil remain stored for future use by shallow-rooted plants.

Mixed croping is another important method for increasing productivity of the soil. In this practice, one main crop and one or two subsidiary crops are grown together on the same ploughing field.

(B) Agrostological Methods

The important agrostological methods for soil conservation are as follows—

(i) **Retiring the Land**—Areas of heavy soil erosion should necessarily be put under thick cover of grasses. Under favourable climatic conditions grazing should also be allowed for certain (short) periods. Grasses have good soil binding capacity. Grasses, such as *Cynodon dactylon, Dectylis glomerata, Eragrostic amabitis*, are proved most effective in binding the soil and in stabilizing the reserves of the bench terrace and sodding water channels.

(ii) **Afforestation and Reforestation—Afforestation** means growing forests at places where there were no forests before owing to lack of seed trees or due to adverse factors such as unstable soil, aridity or swampiness. Reforestation means replanting of forests at places where they have been destroyed.

Trees as windbreaks are planted in deserts which check the velocity of wind. Windbreaks are planted across the area at 90° to the prevailing wind. They check the spread of sand dunes or desert conditions or blowing away of the fertile top soil. Afforestation is applied deserts, where such plants as *Thevetia neriifolia, Tamarindus indica, Dalbergia sissoo, Lowsonia alba, Acacia catechu* serve as useful windbreaks.

(iii) **Lay Farming**—This method of soil conservation aims to grow grasses in rotation with the field crops, which helps in building up the structure of soil and its conservation, preventing soil erosion and improving its fertility.

(C) Mechanical Methods

The mechanical practices of soil conservation include various engineering techniques and structures which are adapted to supplement the biological methods when the latter alone are not sufficiently effective.

Mechanical methods for soil conservation are as follows—

(i) **Pan Breaking**—Soils, in certain areas, become impervious to water and are less reproductive because of formation of hard sheet of clay a few feet below the surface. Such areas can be made productive and water permeable by breaking hard clay pans by means of pan breaker on contour at a distance of about 5 feet.

(ii) **Sub-soiling**—Hard soil, in this method, is broken deeply by means of an implement called sub-soiler without involving the conversion of soil. This process enhances absorption of rain water in the soil and makes the soil more loose and fit to allow luxuriant growth of crops.

(iii) **Basin Leaching**—In this method, a number of small basins (water reservoirs) are made along the contour by means of an implement called **basin blister**. It collects and retain rain water for long period.

(iv) **Contour Terracing**—Sometimes drainage channels or properly spaced ridges or soil mounds are formed along the contour to check soil erosion. These are called **terraces**. Terracing may be of the four types—**Channel terracing, narrow based ridge terracing, broad-based ridge terracing** and **bench terracing**.

(v) **Ponds and Reservoirs**—Small ponds and water reservoirs or dams should also be made at suitable places for irrigation and some other purposes.

(vi) **Gully and Ravine Control**—Heavy rainfall, rapidly running water and transporting water may result in deeper cavities or grooves called **gullies**. Gully formation can be checked by the following methods—

- By growing suitable soil-binding vegetation on the gullies to check soil erosion.
- Diversion trenches should be made available around gullies.
- By making perimeter bunds around gullies to check flow of water through it.

(vii) **Stream Bank Protection**—To grow vegetation alongside the river bank, to construct drains, concrete or stone pitching etc. for checking the cutting and caving of river banks.

Soil Conservation Facilitation

- The erosion of Siwaliks has been studied by **Glover, Hamilton** and **Gorrie** (1951) and suggested **contour trenching** method for soil conservation. This method involves making of a series of deep pits (2' × 1') or trenches across the slope at convenient distance.
- Puri (1954) analysed the problems from different angles and suggested that soil should be kept under tree vegetation in order to check erosional losses and landslides.
- The Central Arid Zone Research Institute **(CAZRI)** in collaboration with **UNESCO** is attempting to check erosional losses in desert region of Rajasthan.

Epilogue

Soil is formed very slowly. It provides us with useful plants. Indiscriminate cutting of plants causes soil erosion. This results in reduction of soil fertility, decrease in crop yield, increase in flood, land slides etc. It is, therefore, very essential that soil is protected by growing natural cover. It not only checks soil erosion but improves amount of rain, reduces floods, increases soil fertility and also provides us with many useful articles. If all possible measures are now taken and implemented seriously and honestly it would save future generation for more serious consequences.

OBJECTIVE QUESTIONS

1. Soil conservation is useful because—
   (A) It maintains efficient use of land and its fertility
   (B) It establishes useful and scientific agriculture
   (C) It keeps the soil placed accordingly
   (D) All of the above
2. Soil conservation is the process whereby—
   (A) Soil is aerated
   (B) Sterile soil is converted to fertile soil
   (C) Soil erosion is allowed
   (D) Top fertile soil is protected against loss
3. Soil erosion is greater where—
   (A) Rainfall is heavy
   (B) Rainfall is low
   (C) There are no winds at all
   (D) None of the above
4. Eroded soils are—
   (A) Unaltered in plant nutrients
   (B) Devoid of plant nutrients
   (C) Rich in plant nutrients
   (D) None of the above
5. The loss of fertile top soil upon which the productivity of agricultural crops, forests and the vegetation depend is called—
   (A) Soil erosion
   (B) Soil conservation
   (C) Terracing
   (D) Contour terracing
6. **Terracing** is an effective method of soil conservation in—
   (A) Desert areas
   (B) Hilly areas
   (C) Plain areas
   (D) None of these
7. **Sheet erosion** is caused by—
   (A) Fast running rivers
   (B) Wind
   (C) Heavy rains
   (D) Glaciers
8. **Mulching** is a process that helps in—
   (A) Moisture conservation
   (B) Weed control
   (C) Soil fertility
   (D) Improvement of soil structure
9. Which of the following functions performed by a forest helps most in controlling drought ?
   (A) Act as water sheds
   (B) Prevention of soil erosion
   (C) Forest bring rain
   (D) Forests have many water plants
10. Process of soil conservation involves—
    (A) Addition of fertilizers
    (B) Aeration of soil
    (C) Protection of soil against loss
    (D) Soil erosion

ANSWERS

1. (D) 2. (D) 3. (A) 4. (B) 5. (A)
6. (B) 7. (C) 8. (A) 9. (B) 10. (C)

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PHYSICAL BASIS OF LIFE : PROTOPLASM

All living things are composed of the essential living substance, **protoplasm**, which has been very aptly described by **T. H. Huxley** (1868) as 'the physical basis of life'. Protoplasm is a soft, jelly-like substance which is always in a state of motion. Protoplasm is composed of water and various substances like proteins, fats, carbohydrates and inorganic salts, but it is, by no means, a mixture of all these materials, which make up 95% by weight of the body. Protoplasm is made up of both inorganic and organic substance. Water the main inorganic substance, varies from 5% to 90% in different tissues, with an average of 70% to 75%.

The following table shows the proportion of various elements in protoplasm :

Element	Weight
Trace elements	0·760
Iron	0·010
Oxygen	62
Carbon	20
Hydrogen	10
Nitrogen	3
Calcium	2·50
Phosphorus	1·14
Magnesium	0·07
Sulphur	0·14
Sodium	0·10
Chlorine	0·16
Potassium	0·11
Iodine	0·014

Physical Nature of Protoplasm

Protoplasm is a greyish, translucent, jelly-like, odourless and viscous substance. It is heavier than water and in contact with it (water) forms a delimiting membrane. It behaves as a moderate conductor of electricity. The physical appearance of protoplasm has been the object of study with many a scientist whose observations have been formulated as various theories.

A. Old Theories :

During the nineteenth century, the following theories were propounded to explain the physical appearance of protoplasm :

1. Alveolar theory : This theory was advanced by **Butschli** (1892). According to this theory, protoplasm consists of bubbles or alveoli of a fluid of lesser density distributed in a fluid of greater density. As a result, the protoplasm looks like a foam or emulsion.

2. Reticular theory : This theory was postulated by **Hastein, Klein** and **Carnoy**. This theory holds that protoplasm consists of numerous minute fibrils interwoven to form a network or reticulum in a fluid medium.

3. Granular theory : This theory was proposed by **Altman** in 1893. According to this theory, the protoplasm consists of numerous fine granules dispersed uniformly in a homogeneous fluid medium.

4. Fibrillar theory : This theory was suggested by **Fisher** (1894) and **Flemming** (1897). This theory maintains that protoplasm consists of numerous minute fibrils or thread-like structures dispersed in a fluid medium.

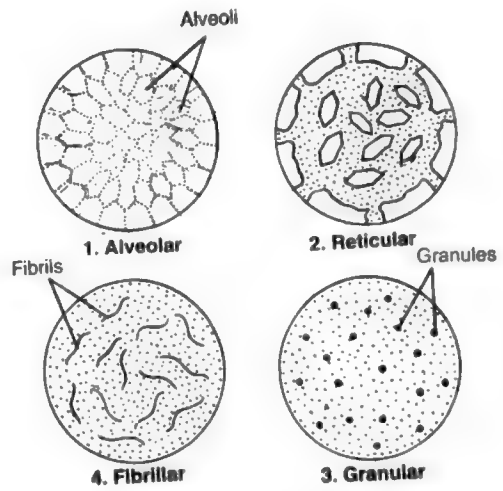


Fig. : (1 to 4) Showing nature of protoplasm according to old theories.

The old theories are of historical importance only. According to these theories protoplasm is supposed to have a fixed or permanent appearance. The present idea, however, shows that in many instance the protoplasm can change from one condition to another.

B. Modern Colloidal Nature (Theory) of Protoplasm :

The modern view is that the protoplasm is a polyphasic colloidal system. This was first suggested by **R. A. Fisher** and **Hardy** (1899), but latter supported by **Wilson** (1925). If consists of a fluid matrix or ground substance **(liquid phase)** and globules of solid and semisolid particles **(dispersed phase)**. The solid and semisolid particles range in diameter from 0·001 to 0·1μ. They are thus too big to dissolve in the matrix to form a **true solution** or **crystalloid** and too small to settle down to form a **suspension**. Thus they remain suspended throughout the matrix forming a **colloidal system**.

The **liquid phase** of protoplasmic colloids consists mainly of water having dissolved inorganic ions and small molecules. The **dispersed phase** comprises mainly the large molecules of proteins, carbohydrates and lipids.

Protoplasm has several following colloidal properties—

1. Colloidal particles are in a constant state of motion. The movement, which can be seen under microscope, is called **Brownian movement**, named after its discoverer **Robert Brown** (1829). It is an irregular movement of

Colloidal particles due to the random bombardment by molecules of the liquid phase (water). The intensity of the Brownian movement depends upon temperature, size of particles and viscosity.

2. Colloidal particles have the property of scattering light. When a beam of light is passed through a Colloidal solution it becomes visible **(Tyndal effect)**.

3. **Sol and gel state :** Colloidal systems possess the property of undergoing changes in consistency or rigidity. A Colloidal suspension can be watery at one time and jelly-like at another. The watery condition is called **sol** state and the semisolid condition the **gel** state. These two states are reversible. In the *sol* state the solid particles of the disperse phase are separate or discontinuous, while the fluid of the dispersion medium is continuous. In the *gel* state the solid particles are continuous while the watery is discontinuous. Both *sol* and *gel* states are found in protoplasm. The conversion from the *gel* state to the *sol* state is called **solation**, while the conversion from the *sol* state to the *gel* state is called **gelation**.

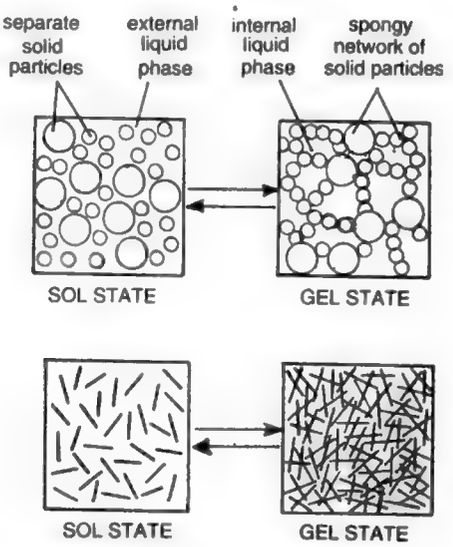


Fig. : Sol and gel phases of a colloid.

4. **Electrical charge :** Protein molecules repulse each other because their overall charge is similar. All molecules are either positively charged or negatively charged. If, however, the molecules approach one another close enough so that valency forces can act, they may be attracted to each other.

5. **Viscosity** : The viscosity at the ground substance of the cell is variable. It may be as low as that at water, or may be very high in the gelating cytoplasm.

6. **Irritability and conductivity :** Protoplasm has the property of irritability, *e.g.*, it responds to stimuli like heat, light and chemicals. It also has the property of conductivity, *i.e.*, of conducting impulses produced by stimuli.

7. **Protoplasmic movements :** Protoplasm exhibits **Streaming movements** at different types which are usually noticed in amoeba, slime moulds and particularly in the plant cells with large vacuoles. Rotatory movements in the cells of leaves of aquatic plants like *Vallisneria* and *Elodea* and circulatory movements in the staminal hairs of *Rhoeo discolor* are the glaring examples. In rotation protoplasm moves in a definite direction along the cell wall whereas in circulation the course of movement is irregular.

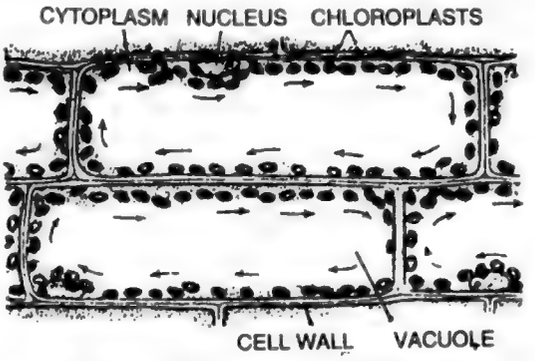


Fig. : Streaming movement (rotation) of protoplasm in a cell of *Vallisneria* leaf.

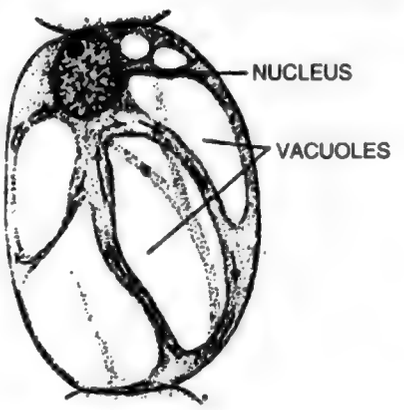


Fig. : Streaming movement (circulation) of protoplasm in a cell of staminal hair of *Rhoeo discolor*.

Besides the movements stated above, commonly called **Cyclosis**, the streaming movements of slime moulds have been observed due to rhythmic contraction and relaxation of protoplasm. This type is called **amoeboid** movement. Rather rapid movement caused by highly sensitive whip-like protoplasmic extensions called **Cilia**, is commonly found in many lower organisms. This movement is known as **Ciliary** movement.

Noteworthy

- **Felix Dujardin** (1835), French protozoologist, studied the jelly-like substance in protozoa and called it **sarcode**.
- **J. E. Purkinje** (1839, 40) named the living substance in the embryos of animals as **protoplasm**.
- **Hugo Von Mohl** (1846) applied the term protoplasm to the contents of the embryonic cells of the plants.
- A German scientist, **Max Schultze** (1861) established the essential similarity that existed between the sarcode and protoplasm.
- **O. Hertwig** (1892) founded the **protoplasmic theory** according to which all living matter, out of which animal and plants are formed, is protoplasm.
- **de Barry** and **Sachs** were of opinion that a multicellular body was a continuous mass of protoplasm which was incompletely subdivided into small centres of activities—the cells, during the development of the body.

Chemical Nature of Protoplasm

The chemical composition of protoplasm, itself a dynamic system, can not be determined by destroying it during analysis process. According chemical analysis,

protoplasm chemically consists of elements, organic and inorganic compounds.

1. Elements :

Nearly 25 elements are reported to occur in protoplasm. Out of these carbon, hydrogen, nitrogen and oxygen are found greatly concentrated in the protoplasm and make up about 99% of all living material. Other essentially occurring elements are phosphorus, calcium, iron, magnesium, potassium and chlorine. The remaining few other elements are iodine, cobalt, boron, manganese, solenium, chromium, molybdenum, silicon and vanadium. Because these latter elements are present in tiny amount (0·1%), they are termed as **trace elements**.

2. Compounds :

In protoplasm most elements occur as chemical compounds, both inorganic as well as organic compounds.

Inorganic Compounds :

(i) Water : Water provides the liquid phase for colloidal protoplasm, a medium for chemical activity in the cells, and the solvent for other substances. It is an indispensable constituent of the protoplasm making up about 75% to 80% of its bulk. This percentage may, however, be as low as 7% to 8% (dormant seeds) and as high as 95% (jelly fishes).

(ii) Inorganic salts : Inorganic salts regulate the osmotic pressure of the protoplasm. Their percentage in protoplasm varies from 1% to 4%. The most common inorganic salts are carbonates, bicarbonates, phosphates and chlorides of calcium, magnesium, iron, sodium and potassium. Mostly they occur as ions in solution with water, *e.g.*, sodium chloride (NaCl) occurs as $Na^+ + Cl^-$ ions, KCl as $K^+ + Cl^-$ and so on. These ions are essential for normal metabolism of cells.

(iii) Gases : Carbon dioxide and oxygen frequently occur in the protoplasm. The latter enters protoplasm for oxidation of complex molecules and the former is produced as a by-product in the process.

Organic Compounds :

The organic matters present in protoplasm are proteins, fats, carbohydrates and nitrogen-base derivatives. They are very complex matters, composed of carbon, hydrogen, oxygen, nitrogen, often sulphur and sometimes phosphorus. The nucleo-proteins occurring in the nucleus in particular are of special significance.

(i) Carbohydrates : Carbohydrates are made up of carbon, hydrogen and oxygen. According to the number of carbon atoms present, carbohydrates are termed monosaccharide **(simple sugars)**, disaccharides **(double sugars)** and polysaccharides **(complex sugars)**. Carbohydrates serve as an important structural material in some animals and plants. The carbohydrates which directly enter into actual constitution of protoplasm are the pentose sugars.

(ii) Fats (lipids) : Fats of protoplasm are heterogeneous compounds. They are composed principally of C, H, O, but they may sometime contain N and P also. Unlike carbohydrates they have a much smaller proportion of oxygen. Lipids fall under the following categories :

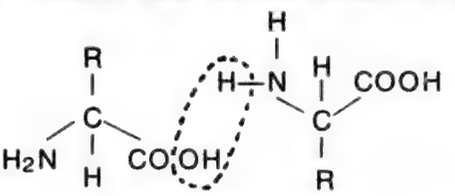
(a) Simple lipids : Simple lipids contain C, H, and O, but with much less oxygen. Their one molecule is formed by the combination of one molecule of glycerol and three molecules of fatty acids.

The common true fats are **triacetin** ($C_9H_{14}O_6$), tripalmitin ($C_{51}H_{98}O_6$) and tristearin ($C_{57}H_{110}O_6$).

(b) Compound lipids : Compound lipids are fat-like substances containing other substances, like phosphoric acid, simple sugar or nitrogenous base (choline), etc., in addition to fatty acid and glycerol or any other alcohol. The common compound lipids are phospholipids (lecithin), lipoproteins and glycolipids (sphingosine).

(iii) Proteins : Proteins, after water, are the most abundant constituent of protoplasm. They are made up of carbon, oxygen, hydrogen and nitrogen, but sulphur, iodine, and some other elements may also occur in them in traces. Proteins are long chain compounds; their simpler components or basic building units are the amino acids. Proteins occur in simple, conjugated and derived forms.

A simple protein consists of about 100 amino acid molecules. However their number varies from 300–1000



in different proteins. Molecular weight of some protein may reach upto 5,00,000.

Proteins are very essential to physical and chemical changes. These are the main constituents of the protoplasm and control several vital activities of the cell. They may also serve energy-rich fuel compounds. Enzymes or the organic catalysts are, in fact, proteins.

(iv) Nucleic acids : The nucleic acids are highly complex polymeric compounds containing carbon, hydrogen, oxygen, nitrogen and phosphorus. These are of two types of nucleic acids—Deoxyribose nucleic acid (DNA) and Ribose nucleic acid (RNA). These constitute 1% of the protoplasm.

Each nucleotide has three components—**nitrogenous bases** (Purine or Pyrimidine), **Pentose sugar** (ribose or deoxyribose) and **Phosphoric acid.**

(v) Other substances—Besides the above major constituents pigments, hormones, enzymes, alkaloides, latex etc., are also found in the protoplasm.

Protoplasm Doctrine

Von Mohl's observations about the importance of protoplasm certainly put the cell theory on a strong foundation. **Schultze** in 1861 put forward the **'protoplasm doctrine'**, stating that all masses of protoplasm are the units of organisation and that protoplasm, in general, is similar in all organisms. The cell was thought to be the mass of protoplasm with a nucleus, which would originate from a pre-existing cell. To this organised mass of protoplasm **Hanstein** (1880) applied the term **protoplast**. The protoplasm doctrine got support from many biologists.

(Coutinued on Page 130)

BOTANY

1. Paddy blast is caused by—
   (A) Algae (B) Fungi
   (C) Bacteria (D) Viruses
2. 'Stem Canker' is caused by—
   (A) Air borne pathogens
   (B) Waterborne pathogens
   (C) Soilborne pathogens
   (D) All of the above
3. In which of the following conditions the photosynthesis is maximum ?
   (A) Intermittent light
   (B) Continuous strong light
   (C) Continuous weak light
   (D) None of the above
4. Which one of the following statements is **not** true ?
   (A) Oogamous sexual reproduction means fusion of motile and a nonmotile gametes
   (B) The first photochemical reaction in photosynthesis is the evolution of molecular oxygen
   (C) The monomeric unit nucleotide in RNA is termed as ribotide
   (D) Proteins and RNA during interphase are synthesized in G_2-phase
5. Equal distribution of extra nuclear material of a cell is brought about by—
   (A) Translation
   (B) Transduction
   (C) Cytokinesis
   (D) Karyrokinesis
6. If the CO_2 were withdrawn from the biosphere which organism would first experience negative effects ?
   (A) Producers
   (B) Primary consumers
   (C) Secondary consumers
   (D) Tertiary consumers
7. According to Hershey and Chase experiment, the genetic material of T_2 bacteriophage is—
   (A) Protein
   (B) DNA
   (C) Both DNA and protein
   (D) None of the above
8. New complementary nucleotides are positioned by the process of—
   (A) DNA replication
   (B) DNA distigration
   (C) Complementary base pairing
   (D) None of the above
9. Which of the following is not concerned with the fructification among Myxomycetes ?
   (A) Glochidium
   (B) Sporangium
   (C) Aethalium
   (D) Plasmodiocarp
10. The seed known by the name of 'Chilgoza', that is used as dry fruit belongs to—
    (A) *Zamia oestica*
    (B) *Cycas revoluta*
    (C) *Pinus gerardiana*
    (D) *Dolichas lablub*
11. The male gamete of *Pinus* is—
    (A) Biciliated
    (B) Nonciliated
    (C) Ciliated or nonciliated depending upon presence or absence of water
    (D) Muticiliated
12. Maximum transpiration occurs through—
    (A) Cuticle
    (B) Lenticels
    (C) Stomata
    (D) Epiblema
13. In succulent plants, the value of R.Q. is—
    (A) Zero
    (B) More than one
    (C) One
    (D) Less than one
14. The common mode of action of herbicide is—
    (A) Blocking of photosystem-I
    (B) Blocking of photosystem-II
    (C) Blocking of xylem
    (D) Blocking of phloem
15. Who observed that other operons in *E. coli* usually exist in the **on** rather than **off** condition ?
    (A) Kleckner
    (B) Watson and Crick
    (C) Morgan
    (D) Jacob and Monod
16. Roots have various adaptations and associations to enhance their ability to—
    (A) Store the product of photosynthesis
    (B) Anchor a plant
    (C) Absorb water and minerals
    (D) All of the above
17. The first layer of cells within the vascular cylinder is—
    (A) Cortex
    (B) Pericycle
    (C) Endodermis
    (D) Epidermis
18. Which of the following mode of nutrition is most likely utilized by a decomposer ?
    (A) Saprophytic
    (B) Parasitic
    (C) Ingestion
    (D) Both B and C
19. The aerobic breakdown of pyruvate within mitochondria results into—
    (A) Water
    (B) CO_2
    (C) 34 ATP
    (D) All of the above
20. Diverse complex organisms appeared in the fossil record of about—
    (A) 600 million years ago
    (B) 600 billion years ago
    (C) 1 million year ago
    (D) 4·5 million years ago
21. Various ribosomes move along the same *m*-RNA at a time which are collectively called—
    (A) Template DNA
    (B) Central dogma
    (C) Polysome
    (D) Nucleosome

22. The antisense RNA is transcribed from the—
(A) Repressible operon
(B) Template DNA strand
(C) CAP
(D) None of the above

23. What happens when tryptophan is present ?
(A) Repressor becomes able to bind to the operator
(B) Repressor becomes unable to bind to the operator
(C) Transcription of structural genes occurs
(D) None of the above

24. Brachysclereids originate from the—
(A) Dermatogen
(B) Phelloderm
(C) Phellogen
(D) None of the above

25. The earliest prokaryotes must have been—
(A) Lipotrophs
(B) Photoantotrophs
(C) Chemoheterotrophs
(D) Chemoautotrophs

26. Geometrically multiplying, rapid population growth rate is known as—
(A) Exponential growth
(B) Population
(C) Demographic transition
(D) Biotic potential

27. Process by which substances become more concentrated in organisms in the higher trophic levels of the food chain is called—
(A) Green house effect
(B) Biological magnification
(C) Acid deposition
(D) All of the above

28. To which Division 'golden-brown algae' belong ?
(A) Phaeophyta
(B) Euglenophyta
(C) Chrysophyta
(D) None of the above

29. Conversion of nitrate to nitrous oxide and nitrogen is called—
(A) Denitrification
(B) Nitrification
(C) Both A and B
(D) None of the above

30. An ecological community is an assemblage of—
(A) Family unit
(B) Interacting populations
(C) Food webs
(D) Closely related species

31. Root cap has no role in water absorption because—
(A) It has no cell containing chloroplast
(B) It bears no root hairs
(C) It has loosely arranged cells
(D) It has no direct connection with the vascular system

32. Absorption of water by root is increased with the—
(A) Increase in transpiration
(B) Decrease in salt uptake
(C) Increase in rate of photosynthesis
(D) Decrease in transpiration

33. The first link in any food chain is a green plant because—
(A) They are firmly fixed to the soil
(B) They alone have the capacity to fix the atmospheric carbon dioxide in the presence of sunlight.
(C) They are abundantly distributed
(D) All of the above

34. The study of development of an organism from the egg to the adult stage is known as—
(A) Genetics
(B) Evolution
(C) Mutation
(D) Embryology

35. Golgi bodies are absent in—
(A) Bacteria
(B) Plants
(C) Animals
(D) All eukaryotic cells

36. Chromatin consists of—
(A) RNA
(B) RNA and histones
(C) DNA and histones
(D) DNA

37. In which of the following the endoplasmic reticulum is more developed ?
(A) Young cells
(B) Bacteriophage
(C) Mature cells
(D) None of the above

38. Conifers are well adapted to withstand extremes of—
(A) Temperature
(B) Humidity
(C) Wind strength
(D) All of the above

39. A fruit which develops from a single ovary of a single flower is—
(A) Simple fruit
(B) Accessory fruit
(C) Pseudocarp
(D) Single fruit

40. Marketed edible part of cashewnut is—
(A) Seed
(B) Cotyledons
(C) Treated thalamus
(D) Thalamus

41. Lomasome is a membranous invagination of the plasmalemma of a/an—
(A) Bacterial cell
(B) Algal cell
(C) Fungal cell
(D) All of the above

42. Parasitic ascomycetes cause—
(A) Leaf curl of peaches
(B) Apple scrap
(C) Chestnut blight
(D) All of the above

43. How many sub-phyla are there in Tracheata according to Tippo's classification of plantae kingdom?
(A) 2 (B) 4
(C) 6 (D) 8

44. Which of the following characteristics is specific for $\phi \times 174$ and M-13 types of viruses ?
(A) Single stranded DNA
(B) Causes cancer
(C) Single stranded RNA
(D) Double stranded DNA

45. To be considered essential, an element must fulfill the criteria—
(A) No other element can substitute and fulfill the same role

(B) It must have an identifiable nutritional role

(C) A deficiency of the element causes the plant to die without completing its life cycle

(D) All of the above

46. Which of the following is correct regarding transition reaction ?

(A) It utilizes NAD^+

(B) It connects glycolysis to the krebs cycle

(C) It gives off CO_2

(D) All of the above are correct

47. Genetic engineering is the use of technology to alter the—

(A) Genome of living cell

(B) Genome of non-living cell

(C) Both A and B

(D) None of the above

48. Cotton dust produces pneumoconiosis or lung fibrosis called—

(A) Hemolysis

(B) Bysinosis

(C) Thrombosis

(D) None of the above

49. The community that initiates the process of succession in a habitat is known as—

(A) Biotic community

(B) Abiotic community

(C) Pioneer community

(D) All of the above

50. The specific sequence of development of a community relating to particular (specific) set of physical and chemical condition is called—

(A) Succession

(B) Climax

(C) Sere

(D) None of the above

ANSWERS

1. (B)	2. (C)	3. (A)	4. (D)	5. (C)
6. (A)	7. (B)	8. (C)	9. (A)	10. (C)
11. (B)	12. (C)	13. (A)	14. (B)	15. (D)
16. (D)	17. (C)	18. (A)	19. (D)	20. (A)
21. (C)	22. (D)	23. (A)	24. (C)	25. (D)
26. (A)	27. (C)	28. (C)	29. (A)	30. (B)
31. (D)	32. (A)	33. (B)	34. (D)	35. (A)
36. (C)	37. (A)	38. (D)	39. (A)	40. (B)
41. (C)	42. (D)	43. (B)	44. (A)	45. (D)
46. (D)	47. (A)	48. (B)	49. (C)	50. (C)

HINTS

1. **Paddy blast** is caused by the fungus *Pyricularia oryzae*. It spreads rapidly under favourable weather conditions. Leaf blast, neck blast and node blast are different phages.

2. Certain plants, *e.g.*, *Mulberry morus* mainly raised by stem-cuttings are greatly aflicted by soil-borne pathogens—*Botrydipodia theobromae*. It causes **stem canker**.

4. During interphase, proteins and RNA are synthesized in G_1-phase.

7. **Hershey** and **Chase** (1952) experiment showed that DNA and not protein is the genetic material of the T_2 bacteriophage.

8. New complementary nucleotides, always present in the nucleus, are positioned by the process of **complementary base pairing**.

9. There are three types of fructifications among Myxomycetes, the **sporogonium, aethalium,** and **plasmodiocarp**.

12. Leaves possess many minute pores called **stomata** through which water vapour diffuses out into the atmosphere. It is called stomatal transpiration. Of the total water lost about 88% water is lost by stomatal transpiration.

13. In succulent plants like *Opuntia* and *Bryophyllum* there is incomplete oxidation of carbohydrates as a result no CO_2 is produced, hence the value of respiratory quotient **(R.Q.)** is **zero**.

15. According to **Jacob** and **Monod**, other operons in *E. coli* usually exist in the **on** rather than **off** condition. For instance, the prokaryotic cell (*E. coli*) produces five enzymes that are needed for the synthesis of amino acid **tryptophan**. If this enzyme is present in the medium, the rest of the enzymes are not produced.

16. Roots have various associations and adaptations to perform their functions, such as anchorage, storage of carbohydrate, absorption of water and minerals.

20. Probably due to the evolution of multicellularity in association with sexual reproduction, diverse complex organisms appeared in the fossil record about 600 million years ago.

22. The antisense RNA can control the expression of a gene in prokaryotes (bacteria). Antisense RNA is transcribed from the **sense DNA strand**.

23. Tryptophan, when present, binds to the repressor. The repressor is then able to bind to the operator and transcription of structural genes does not occur.

24. The brachyslereids found embedded in the cork originate from the **phellogen**.

29. The process of denitrification is the conversion of nitrate to nitrous oxide, while the production of nitrate is nitrification.

30. The community is a general term covering any naturally occuring group of different organisms living together in a certain environment and interacting with each other.

35. Golgi bodies are absent in bacteria and blue-green algae.

36. The chromatin contains DNA, histones (*e.g.*, H_1, H_2A, H_2B, H_3 and H_4) and different types of non-histones.

38. Conifers, which usually have evergreen needle-like leaves, are well adapted to withstand the extremes of temperature, humidity and wind strength.

41. Lomasome is a membranous invagination of the plasmalemma of a fungal cell or hypha. It occurs singly or in groups and situated between the rest of the plasmolemma and the wall material.

43. According to Tippo's classification of kingdom—**Plantae**, there are four sub-phyla in **Tracheata**. The sub-phyla are Sphenopsida, Psilopsida, Pteropsida and Lycopsida.

44. The micro organisms like $\phi \times 174$ and M-13 types of viruses are bacteriophages with single stranded DNA as their genetic material.

(Continued on Page 130)

BOTANY

1. Whisk ferns have no—
   (A) Roots
   (B) Leaves
   (C) Both (A) and (B)
   (D) Rhizome

2. Sleep movement occurs in response to—
   (A) Dark
   (B) Light
   (C) Both (A) and (B)
   (D) Temperature

3. Who produced a procedure for placing bacteria into either a gram-negative or gram-positive type ?
   (A) Pasteur
   (B) Bateson
   (C) Cuenot
   (D) None of the above

4. W.H. 147 is a double dwarf—
   (A) Wheat (B) Cotton
   (C) Rice (D) Sugarcane

5. Who coined the term 'pureline' for the first time ?
   (A) Poehlman
   (B) Dobhzansky
   (C) Johanssen
   (D) Darlington

6. Genes are responsible for growth and differentiation in an organism with the help of regulation of—
   (A) Translation
   (B) Transcription
   (C) Both (A) and (B)
   (D) Transduction

7. A mutation in bacteria results in non-formation of mesosomes. The expected result will be—
   (A) Only replication of DNA will occur
   (B) Only cell division will occur
   (C) Only karyokinesis will occur
   (D) All of the above

8. Mutation was used for the first time for studies on—
   (A) *Oenothera lamackiana* by Lamarck
   (B) *Oenothera lamarckiana* by de Vries
   (C) *Pisum sativum* by Darwin
   (D) *Acetabularia crenulata* by de Vries

9. The most favourable range of wavelength of light used by bacteria for photosynthesis is—
   (A) 70 μm – 100 μm
   (B) 500 – 600 μm
   (C) 700 μm – 900 μm
   (D) 0·25 μm – 3·0 μm

10. The yellow vein mosaic of bhindi is a—
    (A) Bacterial disease
    (B) Viral disease
    (C) Fungal disease
    (D) None of the above

11. The botanical name of water-melon is—
    (A) *Prunus ariculatum*
    (B) *Cencrus graseolata*
    (C) *Melonjana pubescens*
    (D) *Citrullus lanatus*

12. Red rot of sugarcane is caused by—
    (A) *Azospirillum flexile*
    (B) *Cenchrus debaryanum*
    (C) *Colletotrichum falcatum*
    (D) None of the above

13. Difference between one amino acid and another is found in—
    (A) Peptide bond
    (B) R-group
    (C) Carboxyl group
    (D) Amino group

14. Which of the following phages invades the host cell but does not destroy the host ?
    (A) Lytic phage
    (B) Temperate phage
    (C) Virulent phage
    (D) Cyanophage

15. Vascular bundles in which the protoxylem pointing towards the centre are called ?
    (A) Radial
    (B) Exarch
    (C) Endarch
    (D) None of the above

16. To evolve one molecule of oxygen in photosynthesis, the number of quanta of light required is—
    (A) One
    (B) Two
    (C) Thirty eight
    (D) Thirty six

17. Which of the following bacteria do not give off oxygen ?
    (A) Purple sulphur bacteria
    (B) Green sulphur bacteria
    (C) Both (A) and (B)
    (D) None of the above

18. In *Rhizopus*, the main horizontal hypha is—
    (A) Stolon
    (B) Columella
    (C) Rhizoid
    (D) Sporangiophore

19. The science of improving the genetic constitution of the gene pull is known as—
    (A) Palindrome
    (B) Euphenics
    (C) Eugenics
    (D) None of the above

20. DNA fragments can be denatured in alkali and the two strands of the DNA isolated by—
    (A) Denaturation
    (B) Polynucleotide kinase
    (C) Autoradiography
    (D) Electrophoresis

21. A radioisotope used to label proteins differentially from nucleic acid is—
    (A) ^{14}C (B) ^{15}N
    (C) ^{32}P (D) ^{35}S

22. If the cut end of a plant is put in eosine solution, we observe that—
    (A) Phloem gets coloured due to ascent of sap
    (B) Xylem gets stained due to ascent of sap through it
    (C) Leaves remain fresh but ascent of sap is checked
    (D) Leaves wilt as ascent of sap stops

23. In which kingdom would you place multicellular land organisms that carry on photosynthesis ?
(A) Fungi (B) Plantae
(C) Protista (D) Animalia

24. Concepts, based on the conclusions of experiments and observations, are termed as—
(A) Theories
(B) Data
(C) Hypothesis
(D) Scientific method

25. Which of the following statements is/are correct ?
(A) The term 'theory' in science is reserved for those hypotheses that have proven to have the greatest explanatory power
(B) A theory is simply a hypothesis that needs further experimentation and observation
(C) Theories are hypotheses that have failed to be supported by experimentation and observation
(D) All of the above

26. Enzymes carry out—
(A) Condensation of macromolecules
(B) Hydrolysis of micromolecules
(C) Both (A) and (B)
(D) None of the above

27. A hydrophilic group is—
(A) Found in fatty acids
(B) Attracted to water
(C) A polar or ionized group
(D) All of the above

28. Pinnate venation means that—
(A) The branch veins all originate at the point of attachment of the blade to the petiole
(B) The branch veins originate from points along the centrally placed main vein
(C) The veins all originate from the petiole
(D) All of the above

29. Which of the following hormones is considered to be the stress hormone ?
(A) GA_3 (B) ABA
(C) IAA (D) Ethylene

30. Endospores develop in—
(A) *Clostridium* and *Saccharomyces*
(B) *Mucor* and *Bacillus*
(C) *Bacillus* and *Clostridium*
(D) *Clostridium* and *Monococcus*

31. In angiosperms, free nuclear division can occur during the formation of—
(A) Flower (B) Embryo
(C) Gamete (D) Endosperm

32. Asexually produced organism inheriting all the characters of the parent is—
(A) Clone (B) Variety
(C) Hybrid (D) Offspring

33. Auxenotriolic acid was isolated by—
(A) Haagen Smith and Went
(B) Kogl and Haagen Smith
(C) Boysen–Jensen and Kogl
(D) None of the above

34. Which of the following groups of plants produce fibres of great economic value ?
(A) Glycine, Gossypium, Brassica
(B) Cannabis, Hibiscus, Gossypium
(C) Cassia, Gossypium, Lycopersicum
(D) None of the above

35. Which of the following cell organelles is associated with photorespiration ?
(A) Peroxisome
(B) Glyoxysome
(C) Mesosome
(D) All of the above

36. Hornworts are represented by—
(A) Hepaticopsida
(B) Anthocerotopsida
(C) Bryopsida
(D) All of the above

37. Which of the following methods is employed for the isolation of cell organelles ?
(A) Differential centrifugation
(B) Chemical analysis
(C) X-ray diffraction
(D) Autoradiography

38. Which among the following is the smallest angiosperm ?
(A) *Spirodella* (B) *Hydrilla*
(C) *Wolffia* (D) *Lemna*

39. Which of the following plants show ridges and grooves, sunken stomata and chlorenchyma in the stem ?
(A) *Opuntia* (B) *Casuarina*
(C) *Calotropis* (D) *Nerium*

40. Polymers are broken down by—
(A) Condensation
(B) Dehydration synthesis
(C) Both (A) and (B)
(D) Hydrolysis

41. Which of the following is commonly called the table sugar ?
(A) Glucose
(B) Fructose
(C) Sucrose
(D) All of the above

42. Which of the following is / are common polysaccharide in living beings ?
(A) Starch
(B) Glycogen
(C) Cellulose
(D) All of the above

43. Which of the following is a C_4 plant ?
(A) Pea (B) Maize
(C) Papaya (D) Potato

44. Which of the following enzymes is used for carboxylation of **RuBP** ?
(A) Peroxidase
(B) Carboxidismutase
(C)Phosphopentokinase
(D) Hexose kinase

45. Which of the following plant cells will show totipotency ?
(A) Cork cells
(B) Sieve tubes
(C) Meristems
(D) Xylem vessels

46. Development of shoot and root in tissue culture is determined by—
(A) Plant nutrients
(B) Enzymes
(C) Temperature
(D) Cytokinin and auxin ratio

47. Which of the following occurs both during cyclic and non-cyclic modes of photophosphorylation ?
(A) Formation of ATP
(B) Release of O_2
(C) Formation of NADPH
(D) Involvement of both PS-I and PS-II

48. Which of the following physiological effects is caused in plants by gibberellic acid ?
    (A) Rooting in stem cutting
    (B) Yellowing of young leaves
    (C) Shortening of genetically tall plants
    (D) Elongation of genetically dwarf plants

49. The area of plant which receives the stimulus is ?
    (A) Receptive region
    (B) Reactive region
    (C) Perceptive region
    (D) Responsive region

50. TMV genes are—
    (A) Proteinaceous
    (B) Polyribonucleotides
    (C) Single stranded RNA
    (D) Double stranded RNA

ANSWERS

1. (C) 2. (C) 3. (D) 4. (A) 5. (C)
6. (C) 7. (A) 8. (B) 9. (C) 10. (B)
11. (D) 12. (C) 13. (B) 14. (B) 15. (C)
16. (A) 17. (C) 18. (A) 19. (C) 20. (D)
21. (D) 22. (B) 23. (B) 24. (A) 25. (A)
26. (C) 27. (D) 28. (B) 29. (B) 30. (C)
31. (D) 32. (A) 33. (B) 34. (B) 35. (A)
36. (B) 37. (A) 38. (C) 39. (B) 40. (D)
41. (C) 42. (D) 43. (B) 44. (B) 45. (C)
46. (D) 47. (A) 48. (D) 49. (C) 50. (B)

HINTS

1. Psilophytes are whisk ferns. The whisk ferns have no leaves or roots. A branched rhizome has rhizoids and a mycorrhizal fungus helps gather nutrients.

2. A sleep movement is a nastic response that occurs in response to dark and light. Sleep movement is also caused owing to changes in pulvinus situated at the base of leaf.

3. H.C. Gram (1884) discovered a procedure for placing bacteria into either a gram-positive or a gram-negative depending on whether or not the organisms retained crystal violet stain.

4. **W. H. 147** is a double dwarf wheat with excellent yielding potency under natural conditions and either free from rusts or with high degree of resistance to rusts.

7. Non-formation of mesosomes refers to non-elongation of protoplasm. Because protoplasm and hence mesosomes to which the DNA attaches during cell division acts as spindle fibres and its inactivity causes suspension of process of complete cell division.

9. A bacterium photosynthesizes by absorbing light of infra-red region having wavelength ranging from 700 μm to 900 μm.

10. 'Yellow vein mosaic' is a viral disease of bhindi that occurs in severe form during March to June when the temperature is high. The virus is transmitted by white-flies (*Bemisia tabaci*).

12. The 'red rot' of sugarcane disease is caused by *Colletotrichum falcatum*. Once the fungus enters the host, it grows rapidly producing septate mycelium. The hyphae in ducts of fibrovascular bundles or in any centre of infection grow rapidly.

13. Polarity and non-polarity are important aspects of R-groups. There are twenty different amino acids in cells that differ only in possessing their R-groups.

14. Certain bacteriophages, such as lambda phages, have entirely different pattern of life cycle which is called **lysogeny** and is characterised by lysis after phage infection. A virus with this capacity is called **temperate.**

16. Non-cyclic photophosphorylation occurs twice and four water molecules are photolyzed to evolve one molecule of oxygen during photosynthesis, in which one quanta of light is required.

17. Green sulphur bacteria and purple sulphur bacteria do not give off oxygen because they do not use water as an electron donor.

23. Kingdom-plantae includes multicellular organisation with specialized and complex cells. The representative organisms are ferns, mosses, woody, non-woody flowering plants.

24. The ultimate goal of science is to understand the natural world in terms of **theories** which mean concepts based on the conclusions of experiments and observations.

26. Enzymes carry out both condensation (building up) and hydrolysis (breaking down) of macromolecules.

28. Leaf veins are vascular bundles within a leaf. Monocots exhibit parallel venation and dicot exhibit netted venation which may be either pinnate or palmate.

29. Abscisic acid (ABA) is sometimes called the stress hormone because it initiates and maintains seed and bud dormancy and brings about the closure of stomata.

31. In angiosperms, free nuclear divisions occur invariably during formation of embryo sac/female gametophyte and two types of endosperm (nuclear and helobial).

32. Cloning means the production of exact genetic replicas of an individual. In other words, a clone can not be considered as an offspring, but simply the copy of a given individual.

34. *Cannabis, Hibiscus* and *Gossypium* produce respectively hemp, deccan hemp and cotton (fibre) respectively.

35. Peroxisome is associated with photorespiration. Peroxisome is a kind of microbody. Peroxisome contains typical enzyme involved in glycolate metabolism and photorespiration.

36. The class-Anthocerotopsida (Anthocerotae) embraces a small but very clearly defined groups of plant. (bryophytes) which differ in many ways, especially in their sporophytes from the liverworts to which they are often allied. Popularly the members of this class are called **hornworts.**

37. **Differential centrifugation—** The separation of mixtures such as cellular particles in a medium at various centrifugal forces to separate particles of different density, size and shape from each other.

(Continued on Page 132)

BOTANY

1. 'Seed rot' of chickpea is caused by—
   (A) *Rhizoctonia solani*
   (B) *Pythium debaryanum*
   (C) *Claviceps purpurea*
   (D) None of the above
2. EUS stands for—
   (A) European Union for Silviculture
   (B) Eradication and Use of Soil plants
   (C) Epizootic Ulcerative Syndrome
   (D) Etiolation and Unity of Sympatric species
3. **J. E. Purkinje**, who coined the term protoplasm to describe the contents of cells, was a/an—
   (A) English biologist
   (B) American biologist
   (C) Czech biologist
   (D) Dutch biologist
4. The branch of cytology which deals with the chemical and physio-chemical analysis of living matter is termed as—
   (A) Cytotaxonomy
   (B) Cytogenetics
   (C) Cytoecology
   (D) Cytochemistry
5. Tropical rain forest destruction is considered to be extremely serious because—
   (A) Mostly large tracts of forest absorb carbon dioxide, reducing the threat of global warming
   (B) It leads to the severe massive destruction in biological diversity
   (C) Tropical soils will not support agriculture for future
   (D) All of the above
6. Hydrocarbons and nitrogen oxides in the environment interact to form—
   (A) Ozone and PAN
   (B) Aerosols
   (C) Sulphur dioxide
   (D) None of the above
7. Down's syndrome—
   (A) Is more prevalent among children of elderly mothers after the age of forty or above
   (B) Provides no overt abnormalities
   (C) Is always by non-disjunction of chromosome 21
   (D) Is always caused by non-disjunction of chromosome 17
8. Continental drift causes—
   (A) Geological catastrophe like earthquake
   (B) Mass extinction
   (C) Fossilization and distribution of fossils on the earth
   (D) All of the above
9. Calicolous plants usually found in soil with pH—
   (A) 8 (B) 7
   (C) 6·5 (D) 4
10. The soil which develops *in situ* above parent bedrock is known as—
    (A) Sedentary soil
    (B) Embryonic soil
    (C) Secondary soil
    (D) Eolin soil
11. Plants having feebly developed root, soft-delicate stem and large number of air cavities, are mostly grouped under—
    (A) Xerophytes
    (B) Mesophytes
    (C) Hydrophytes
    (D) Helophytes
12. Guttation, in the morning, occurs when—
    (A) The rate of water absorption and root pressure are higher
    (B) The rate of water absorption is higher and the rate of root pressure is lower
    (C) The rate of water absorption is lower and the rate of root pressure is higher
    (D) When both water absorption and root pressure are lower
13. Strap-like ligulate corolla of sunflower is represented by—
    (A) Immature florets
    (B) Ray florets
    (C) Disc florets
    (D) All of the above
14. The ultimate branches of leaves are very small and terminate in bundle ends which bend into minute specialized photosynthetic areas known as—
    (A) Mesophyll
    (B) Palisade
    (C) Vein islets
    (D) Transition zone
15. Industries, in air pollution, are—
    (A) Area sources
    (B) Line sources
    (C) Point sources
    (D) All of the above

ANSWERS WITH HINTS

1. (A) 2. (C) 3. (C) 4. (D) 5. (D)
6. (A) 7. (C) 8. (D) 9. (C) 10. (A)
11. (C) 12. (A) 13. (B) 14. (C) 15. (C)

1. The fungus—*Rhizoctonia solani* causes 'seed rot' of chickpea. It is one of the important pathogens in chickpea wilt complex.
2. EUS (Epizootic Ulcerative Syndrome) is common bacterial disease which appears as sites of localized external infections.
7. When members of a homologous chromosome pair fail to separate during meiosis-I, is called **non-disjunction**. The most common

(Continued on Page 132)

Reasoning in Physics

Q. Why the spring is made of steel and not of copper ?

Ans. We know that the elasticity of steel is more than that of copper. Therefore, for equal applied force, the elongation of steel spring is less than that of copper for same initial length. So the steel spring can bear a larger tension before the elastic limit is crossed. Moreover, steel recovers its original state quicker than copper after the deforming force is removed.

Q. Which one of the glass and rubber is more elastic and why ?

Ans. Glass is more elastic than rubber because for a given applied force per unit area, the strain produced in glass is much smaller than produced in rubber.

Q. During certain wind storm, light roofs are blown off, why ?

Ans. During the storm, the velocity of wind above the roof surface is very high and hence pressure is low. The pressure below the roof is atmospheric which is higher than the pressure of upper surface. Due to this pressure difference, the roof blows.

Q. Why are the upper surface of the wings of an aeroplane made convex upwards and the lower, concave downwards ?

Ans. This design of the wings makes the velocity of air larger at the upper surface and smaller at the lower surface. So the pressure on the upper side is less than the pressure on lower side. The pressure difference provides lift to the wing of the plane.

Q. Why does a small quantity of a liquid assume spherical form ?

Ans. The small quantity of liquid assumes the spherical form due to surface tension which tends to reduce the surface area. A given mass will acquire minimum surface area if it assumes a spherical shape.

Q. How does the impurity affect the surface tension ?

Ans. If the impurity added is highly soluble in the liquid, the surface tension increases while for the impurity which is less soluble in liquid, the surface tension decreases.

Q. Explain why a beaker filled with water at 4°C over-flows if the temperature is decreased or increased.

Ans. The reason is the anomalous expansion of water. The maximum density of water occurs at 4°C. So the water expands whether it is heated above 4°C or cooled below 4°C.

Q. If an inflated tyre bursts, the air escaping out is cooled, why ?

Ans. When the tyre bursts, there is adiabatic expansion of air because the pressure of air inside is sufficiently greater than atmospheric pressure. In expansion, the air does some work against surroundings and so the internal energy decreases. This causes a fall in temperature.

Q. Stainless steel and cooking pans are preferred with extra copper bottom, why ?

Ans. We know that the conductivity of copper is large as compared to the conductivity of steel. Therefore, when a cooking pan, fitted with extra copper sheet is placed over a flame, more heat passes. This causes early cooking of food.

Q. Why does an air bubble in a jar of water shine brightly ?

Ans. When the rays go from water into the air bubble, they suffer total internal reflection. Now they are reflected back as if from a mirror. Hence the air bubble shines like a mirror.

Q. Why does the setting sun look red ?

Ans. This is due to the phenomenon of scattering of light. When the rays of white light coming from the sun near the horizon pass through the atmosphere, the blue rays are scattered transversely by air molecules. These rays are unable to reach the earth. On the other hand, red rays are scattered least. So these rays reach the observer on the earth. That is why, the sun now appears red.

Q. What is meant by the power of a lens ?

Ans. The power of a lens is defined as its ability to deviate the rays towards the axis. This is the reciprocal of the focal length expressed in metre. Hence,

$$P = \frac{1}{f \text{ (in metre)}} \text{ diopter}$$

The power of a convex lens is positive while that of a concave lens is negative.

Q. What are the main differences in the spectra of sodium flame, the sun, incan-descent bulb filament and neon bulb ?

Ans. The spectrum of sodium flame consists of two yellow bright lines. The suns spectrum is continuous consisting of many dark lines called Fraunhoffer lines. The spectrum of incandescent bulb filament is continuous having all colours from red to violet in order. These colours are not clearly separated from each other. In neon bulb spectrum, there are separate bright lines of all colours.

Q. The diameter of the sun is of the order of 10^9 metre, still it appears to be a small disc, why ?

Ans. The distance of the sun from the earth is of the order of 10^{11} metre. It subtends an angle $\frac{10^9}{10^{11}} \approx 10^{-2}$ radian (very small) at one eye. The same angle is subtended by a dise of 1 cm diameter placed at a distance of 1 metre from our eye. So the sun appears first like a small disc.

Q. For what wavelength of light is our eye most sensitive ? What is value in lumen/watt corresponding to this wavelength ?

Ans. Our eye is most sensitive to 5550 Å wavelength corresponding to this wavelength the value of luminous flux/radiant flux = 685 lumen/watt. ●●●

Reasoning in Chemistry

(Why and How)

Q. 1. Solution of $[V(OH)_4]^+$ is practically colourless whereas $[V(OH)_2]^{2+}$ is blue. Why ?

Reason—Solution of $[V(OH)_4]^+$ is colourless because in + 5 oxidation state of vanadium there is no unpaired electron which can absorb light in the visible region. Solution of $[V(OH)_2]^{2+}$ is blue as the oxidation state of vanadium in this ion is + 4 and contains one unpaired electron in its *d*-orbital. This electron can be excited to higher *d*-level of the same shell by low energy photons which have frequency in the yellow region of the spectrum. Hence the light transmitted by the solution appears blue.

Q. 2. Why neutron is preferred most as a projectile over others like proton, deuteron, triton, α-particles etc. ?

Reason—Charged particles like proton, deuteron, triton, α-particle etc. reach the target (positively charged nucleus) with a great difficulty due to coulombic force of repulsion (being positively charged these are repelled back by the nucleus). To overcome this coulombic repulsion highly energetic charged particles as projectile are needed. Howsoever neutron has no charge and, therefore, experiences no coulombic repulsion.

Q. 3. Why a new generation of reactors (breeder reactors) are coming up to replace traditional nuclear reactors ?

Reason—In breeder reactors more fuel element is produced than what is consumed during the generation of energy. New fuel element is produced from a non fissile nuclei.

$_{92}U^{238}$ is bombarded with a fast neutron to produce $_{94}Pu^{239}$, a fissionable nuclei

$$_{92}U^{238} + {}_0n^1 \rightarrow {}_{92}U^{239} \rightarrow {}_{93}Np^{239} + {}_{-1}e^0.$$

$$_{93}Np^{239} \rightarrow {}_{94}Pu^{239} + {}_{-1}e^0$$

In breeder reactors the conditions are, so controlled that out of 3 neutrons emitted in fission of each $_{92}U^{235}$ only one is used to propagate the fission chain with $_{92}U^{235}$. The other two are allowed to react with $_{92}U^{238}$ and not being absorbed by Cd steel (as occurs in traditional nuclear reactors). Thus two fissible nuclei of $_{94}Pu^{239}$ are formed for one $_{92}U^{235}$ nucleus is consumed.

Q. 4. In general the rate of a reaction decreases as time passes. Explain why ?

Reason—The rate of reaction is directly proportional to the product of molar concentration of reactants (Law of mass action). As the time passes the concentration of reactants is decreased and thereby the rate of reaction also decreases.

Q. 5. The carbon dioxide dissolved in water would increase the rate of rusting. Why ?

Reason—CO_2 dissolves in water to form carbonic acid (H_2CO_3) which dissociates as follows

$$CO_2 + H_2O \rightarrow H_2CO_3 \rightleftharpoons 2H^+ + CO_3^{2-} \quad ...(i)$$

The net reaction in the rusting of iron is represented as

$$4Fe_{(s)} + 3O_{2_{(g)}} + 12H^+_{(aq)} + H_2O \rightleftharpoons 4Fe^{3+} + 7H_2O \quad ...(ii)$$

According to Le Chatelier's principle, an increase in the concentration of reactant would favour forward reaction. In presence of CO_2, H^+ ions concentration is increased (equation 1) which appears as reactant in equation (2). Thus CO_2 increases the rate of rusting of iron.

Q. 6. Why sodium metal is not deposited when NaCl solution is electrolysed using Pt electrodes ?

Reason—In aqueous solution of sodium chloride there are present Na^+, Cl^-, H^+ and OH^- ions and unionised H_2O. At the cathode either Na^+ or H_2O is reduced.

$$Na^+_{(aq)} + e \rightarrow Na_{(s)} \qquad E^\circ = -2{\cdot}71\ V$$

$$H_2O + e \rightarrow \frac{1}{2}H_{2_{(g)}} + OH^-_{(aq)} \qquad E^\circ = -0{\cdot}83V$$

Though E° values for both the reactions are negative, one with small negative value takes place in preference over the other. Hence water is reduced to liberate H_2 at cathode and reduction of $Na^+_{(aq)} + e \rightarrow Na_{(s)}$, does not occur.

Q. 7. Molar conductivity of acetic acid increases with dilution of the solution. Why ?

Reason—On dilution the degree of ionisation of acetic acid increases ($CH_3COOH \rightleftharpoons CH_3COO^- + H^+$) and thereby number of anions and cations is increased, which causes a sharp increase in molar conductivity of acetic acid with dilution.

Q. 8. Metallic conductance decreases while electrolytic conductance increases with increase in temperature. Why ?

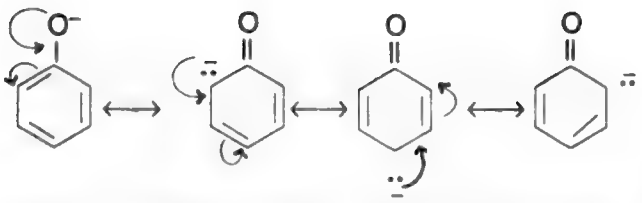
Reason—Increase in temperature increases the mobility of anions and cations of the molten electrolytes (or the ions in solution). Further, viscosity of the solvent is also decreased with increase of temperature, thus the ion in solution experience less resistance, and conduct more electricity at high temperature.

On the other hand increase in temperature increases the movement of the Kernels in the metals which offers more resistance to the flow of electrons.

Q. 9. Why phenol is acidic ?

Reason—The acidic nature of phenol is due to the formation of phenoxide ion which is resonance stabilised

$$C_6H_5OH + H_2O \rightleftharpoons \underset{\text{Phenoxide ion}}{C_6H_5O^-} + H_3O^+$$



The negative charge is spread throughout the benzene ring. Charge delocalisation is a stabilising factor in phenoxide ion.

Q. 10. HCl is a strong acid in water but weak acid in glacial acetic acid. Why ?

Reason—Strength of an acid depends on the 'ease' with which it can donate a proton in solution. HCl in water donates proton very easily to yield Cl^- ion and, therefore, it is a strong acid.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

In glacial acetic acid there is a competition for donating proton between HCl and CH_3COOH (both have proton donating tendency). HCl forceibly donates proton to acetic acid with difficulty. Hence HCl behaves as a weak acid.

$$HCl + CH_3COOH \rightleftharpoons CH_3COOH_2^+ + Cl^-$$

Q. 11. Bohr's atomic model violates the uncertainty principle. Why ?

Reason—Uncertainty principle tells us that it is not possible to determine with accuracy both the position and momentum of an electron at the same moment. Bohr's atomic orbit describes simultaneously both the location and momentum of electron (Recall an electron moving in an orbit of definite energy states) and thus violates Heisenberg's uncertainty principle.

Q. 12. Why cresols are less acidic than phenol ?

Reason—Presence of electron releasing group ($-CH_3$) (in cresols) on benzene ring decreases the acidic nature of phenol as it strengthens the negative charge on phenoxy oxygen and thus proton release becomes difficult. Hence cresols are less acidic than phenol.

Q. 13. Aniline undergoes bromination in *o*-and *p*-position but in presence of strong acid it gives *m*-bromo aniline. Why ?

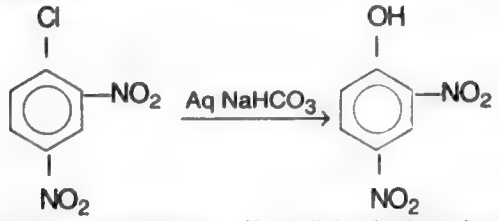
Reason— $-NH_2$ group is *o*-and *p*-directing. However, in presence of strong acid aniline combines with proton to form $C_6H_5\overset{+}{N}H_3$ and $-\overset{+}{N}H_3$ group is *m*-directing. Thus *m*-bromo product is formed in presence of strong acid.

Q. 14. Although benzene is highly unsaturated, it does not undergo addition reactions?

Reason—π electrons of benzene ring are delocalised throughout the molecule. This makes the molecule very stable. The addition reactions would result in the breaking of this delocalisation, *i.e.*, the stability of the molecule which is resisted.

Q. 15. In the preparation of 2 : 4 dinitro chlorobenzene from chlorobenzene, by nitration, the reaction product should not be washed with aqueous solution of $NaHCO_3$ to remove the unused acid. Why ?

Reason—2 : 4 dinitro chlorobenzene shows nucleophilic substitution reaction, *i.e.*, —Cl can be replaced by —OH group in presence of $NaHCO_3$ which makes the solution alkaline



(2 : 4 dinitro chloro benzene) (2 : 4 dinitro hydroxy benzene)

●●●

TRUE OR FALSE

Physics

1. An empty vessel produces louder sound than a filled one of the same shape and size when struck in the same way.

—T/F

2. When a silicon semiconductor is doped with a boron atom it behaves as *p*-type semiconductor.

—T/F

3. The ratio of de Broglie wavelength of an electron and a proton moving with same kinetic energy is $\sqrt{1840}$.

—T/F

4. By applying magnetic field γ-rays can be deviated.

—T/F

5. Coloured glass appears white after being crushed into fine powder.

—T/F

6. If an ideal gas expands adiabatically, it does positive work and its internal energy decreases.

—T/F

7. In an SHM when the displacement in one half the amplitude, the kinetic energy is three-fourth of the total energy.

—T/F

8. In an SHM, kinetic and potential energies become equal when the displacement is $\frac{1}{\sqrt{2}}$ times the amplitude.

—T/F

9. Bridges are declared unsafe after a long use.

—T/F

10. A balloon filled with helium does not rise in air indefinitely but haults after a certain height (neglecting winds).

—T/F

11. Absolute zero degree temperature is not zero energy temperature.

—T/F

12. Solids can support both longitudinal and transverse waves but only longitudinal waves can propagate in gases.

—T/F

13. The principle of superposition is applicable to LASER waves.

—T/F

14. Conversion of heat into work is not possible without a sink at lower temperature.

—T/F

15. Stainless steel cooking pans are preferred with extra copper bottom.

—T/F

Chemistry

16. Water gas is a mixture of CO and H_2.

—T/F

17. Carbon dioxide is absorbed by plants in the presence of sunlight to form glucose and higher carbohydrates.

—T/F

18. At ordinary temperature all oxides of nitrogen are in the gaseous state.

—T/F

19. Aniline dissolves in aqueous HCl to form anilinium chloride.

—T/F

20. Formic and acetic acids are both powerful reducing agents.

—T/F

21. Ethylmethyl ketone can have only following tautomeric forms.

$$CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3 \rightleftharpoons CH_3CH_2-\overset{OH}{\overset{|}{C}}=CH_2$$

—T/F

22. The boiling point of propionic acid is less than that of *n*-butyl alcohol, an alcohol of comparable molecular weight.

—T/F

23. Reaction of phenol with benzoyl chloride in alkaline solution, is known as Schotten-Baumann reaction.

—T/F

24. Ammonium chloride can be replaced by ammonium sulphate in the precipitation of group III radicals.

—T/F

25. Argon is most abundant noble gas in atmosphere.

—T/F

26. The number of monodentate ligands attached to the central atom is the coordination number of the central atom.

—T/F

27. Molecularity of a reaction can be zero but the order of a reaction can never be so.

—T/F

28. Milk is an example of emulsion.

—T/F

29. If the pressure is increased, the equilibrium reaction will take place in a direction which will bring about lowering of pressure.

—T/F

30. Expansion work is given by the expression $P\Delta V$.

—T/F

Zoology

31. Synovial joints have fluid-filled capsules of fibrous connective tissue.

—T/F

32. Hybridization based techniques use probes to detect nucleic acid sequences.

—T/F

33. Heartbeat or cardiac cycle consists of a contraction and relaxation.

—T/F

34. Genotoxicity refers to the detection of agents that damage protein.

—T/F

35. Thymus is a lymphatic organ located in the upper chest region near the neck.

—T/F

36. Cancerous tumours arising from epithelial tissues are called sarcomas.

—T/F

37. The pacemaker or sinoatrial node is a collection of specialized cardiac muscle cells in the right atrium, which sets the heart beat.

—T/F

38. Synthesis of pyruvic acid, glucose or glycogen from amino acids is called glycogenesis.

—T/F

39. Urine formation begins within the nephron as fluid and small molecules filter through the glomerulus into the glomerular capsule.

—T/F

40. The cavity of medulla oblongata is called third ventricle.

—T/F

41. The ampullae of lorenzini is a photosensitive organ in Scoliodon.

—T/F

42. Galactosemia is the inability to metabolize starch.

—T/F

43. Freshwater bony fishes maintain water balance by excreting a hypotonic urine.

—T/F

44. The limbic system involves both the unconscious and conscious brain.

—T/F

45. Transmission of the nerve impulse across a synapse is accomplished by the movement of Na^+ and K^+.

—T/F

Botany

46. The skeleton of the shoot is formed by the stem.

—T/F

47. Flower buds are also buds but they are modified to carry on the special function of reproduction.

—T/F

48. While the stem is growing, lateral buds grow at every leaf axil in basipetal order.

—T/F

49. The genetic material must be able to store information, be replicated, and do not undergo mutations.

—T/F

50. Enzymatic digestion of the transforming substance with DNase, an enzyme that digest DNA, does not prevent transformation.

—T/F

51. Complementary of base pairing and joining, during replication of DNA, are carried out by a complex called DNA polymerase.

—T/F

52. The genetic code is a triplet code but each codon consists of four bases.

—T/F

53. Most common method of asexual reproduction in chlorophyta is by the formation of zoospores.

—T/F

54. The whole enzyme molecule called holoenzyme is made up of a proteinous part and a cofactor, the prokinaceous part is called prosthetic group.

—T/F

55. IAA is not a common naturally occurring auxin.

—T/F

56. The reduction of CO_2 takes place in the stroma of chloroplast by means of a series of reactions called Calvin cycle.

—T/F

57. Transposons are also called jumping genes.

—T/F

58. Trophic levels are formed by organisms associated with food chains.

—T/F

59. *Nitrite reductase* is the enzyme, responsible for the reduction of molecular nitrogen to the level of ammonia in the leguminous root nodules.

—T/F

60. If a homozygous recessive white-flowered plant is crossed with a homozygous dominant red-flowered plant. the offspring will be all red-flowered.

—T/F

ANSWERS

1. True	2. True	3. True	4. False
5. True	6. True	7. True	8. True
9. True	10. True	11. True	12. True
13. False	14. True	15. True	16. True
17. True	18. False	19. True	20. False
21. False	22. False	23. True	24. False
25. True	26. True	27. False	28. True
29. True	30. True	31. True	32. True
33. True	34. False	35. True	36. False
37. True	38. False	39. True	40. False
41. False	42. False	43. True	44. True
45. False	46. False	47. True	48. False
49. False	50. True	51. True	52. False
53. True	54. False	55. False	56. True
57. True	58. True	59. False	60. True

HINTS

1. When an empty vessel is struck, the air volume inside the vessel vibrates with sufficiently large amplitude. As the loudness of sound depends on the amplitude of the wave, it produces a large sound.

   In a fully filled vessel, liquid inside can not be set into vibration with a large amplitude. This is mainly due to damping of the vibration in presence of the liquid.

2. Boron is an element belonging to third group of the periodic table having three valence electrons. When boron is doped as impurity in a pure crystal of germanium or silicon, the valence electrons of the impurity atom form covalent bonds with the nearby crystal atoms and in bonding one bond remains vacant. The vacant bond can accept one electron and is equivalent to a positive charge. The extrinsic semiconductor thus formed is a *p*-type semiconductor.

3. We know that the wavelength associated with a particle is $\lambda = \frac{h}{\sqrt{2mE}}$. For an electron $\lambda_e = \frac{h}{\sqrt{2m_eE}}$

   and for proton $\lambda_p = \frac{h}{\sqrt{2m_pE}}$.

   $\therefore \quad \frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}} = \sqrt{1840}$

4. γ-radiations are electromagnetic radiations which are chargeless. So they are not deviated by electric or magnetic fields.

5. When the glass is crushed into fine powder the light incident is totally scattered without the absorption so due to the composite light crushed glass appears white.

6. When an ideal gas expands adiabatically, its internal energy is consumed, so its temperature decreases. The heat energy from the environment is not flowing to the system to increase its internal energy and bring it to the initial stage. Hence, internal energy decreases. Since, work is done by the system, work done is positive.

   For adiabatic change

   $$\Delta Q = 0$$

   $\therefore$ From first law of thermodynamics

   $$0 = \Delta W + \delta U$$

   or, $$\Delta W = -\delta U$$

   Thus, the system does a positive work and the internal energy of the gas decreases.

9. A bridge during its long use undergoes continuous alternating strains a very large number of times each day and after a long period due to loss of strength, the amount of strain in the bridge for a given stress will be large and many ultimately lead to the collapse of the bridge.

12. The gases possess only volume elasticity. As such in gases, only longitudinal waves can be transmitted. On the other hand, the solids possess both volume and shear elasticity and likewise both the longitudinal and transverse waves can be transmitted through them.

16. Water gas is obtained by passing superheated steam over red hot coke at 450 – 600°C.

$$\underset{\text{Red hot coke}}{C} + \underset{\text{Steam}}{H_2O} \longrightarrow \underset{\text{Water gas}}{CO + H_2}$$

17. This process is known as photosynthesis

$$6CO_2 + 6H_2O \xrightarrow{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

18. N_2O_5 is white crystalline solid (m.p. 30°C).

19. The solubility of Aniline in dil. HCl is due to the formation of water soluble salt.

$$C_6H_5NH_2 + H_3O^+ + Cl^- \longrightarrow \underset{\text{Anilinium Chloride}}{C_6H_5NH_3^+Cl^-} + H_2O$$

20. Only formic acid is a reducing agent.

21. It has two enolic forms I and II. II is more stable because it has a more substituted double bond.

$$\underset{\text{(I)}}{CH_3CH_2-\overset{\overset{OH}{|}}{C}=CH_2} \qquad \underset{\text{(II)}}{CH_3CH=\overset{\overset{OH}{|}}{C}-CH_3}$$

(Continued on Page 135)

FILL IN THE BLANKS

Physics

1. The path of a projectile fired horizontally is .....
2. According to Laplace, the propagation of sound through air is an ..... process.
3. Magnetic flux linked with a surface is maximum when area is held ..... to the direction of field.
4. Einstein's photoelectric equation is $\frac{1}{2}mv^2 =$ ..... $(\nu - \nu_0)$.
5. ${}_0n^1 + {}_{92}U^{235} \longrightarrow {}_{56}{}^{\cdots\cdots}{}^{141} + {}_{36}Kr^{92} + 3\,{}_0n^1 + Q$.
6. Units of mutual conductance in a triode valve ..... .
7. The position of a body with respect to time is given below :

   $$x = 2t^3 - 6t^2 + 12t + 6$$

   If $t = 0$, the acceleration is .....
8. The working of a rocket is based on .....
9. The relative velocity of two particles in a head-on collision remains unchanged both in ..... and .....
10. The relation in rotatory motion analogous to $\vec{P} = m\vec{v}$ in uniform circular motion is .....
11. According to Kepler's second law, the radius vector to a planet from the sun sweeps out equal area in equal intervals of time. The law is a consequence of conservation of .....
12. Excess pressure inside a liquid drop of radius *r* and surface tension T is .....
13. The pressure at all points lying at the same depth in a liquid is .....
14. A mixture of gases can be separated by using .....
15. Sound wave is a ..... wave while light wave is an ..... wave.

Chemistry

16. The vapour density of a diatomic gas is 25, its atomic weight is .....
17. A face centered unit cell of X atoms (or ions) will always contain ..... net X atoms (or ions) within the cell.
18. Entropy of a perfectly crystalline solid is ..... at absolute zero.
19. Mass of a substance produced or consumed at an electrode in the electrolysis is ..... proportional to the quantity of electricity passed through the electrolyte.
20. Amino group ..... the benzene ring towards electrophilic substitution.
21. Benzyl alcohol and phenol can be distinguished by using ..... solution.
22. The *sp* hybridisation in a molecule leads to ..... structure.
23. A carbon atom having ..... groups attached to itself is known as asymmetric carbon atom.
24. Electrophiles attack the benzene ring where the electron density is .....
25. Colour of nickel sulphide is black and that of zinc sulphide is .....
26. The IUPAC name of $[Co(NH_3)_6]Cl_3$ is .....
27. Chemical composition of rust is .....
28. Alloys of Hg with other metals are called .....
29. Arsenic sulphide sol carries a ..... charge.
30. The ideal solution is one that obeys ..... law.

Zoology

31. A gene pool consists of all ..... at all gene loci in all ..... of the population.
32. Genetic drift in a new colony is known as the ..... effect.
33. A change in the gene pool of a small population due to chance is called .....
34. Recombinant DNA is a DNA molecule carrying a new combination of .....
35. A person with sickle-cell anemia is ..... for the alleles at that locus.
36. The ultimate source of all genetic variation is ..... as they yield new alleles.
37. Heterozygosity protects ..... from natural selection.
38. An X-linked, recessive allele is much more likely to be expressed in ..... than in .....
39. A viral genome incorporated into the DNA molecule of a bacterium is called a .....
40. Exchange of genetic material by direct cell-to-cell contact in bacteria is known as .....
41. A promoter in the DNA controls the rate at which constitutive genes are .....

42. The enzyme that facilitates synthesis of copy of DNA is ....., made naturally by .....
43. During glycolysis ..... and ..... are removed from the substrate and picked up by .....
44. Genes that code for polypeptides are called ..... genes, whereas genes that activate or inactivate other genes are called ..... genes.
45. Plasmids that can integrate into the bacterial DNA are called .....

Botany

46. Chromosome puffs or Balbiani rings are present on the swellings of bands of the ..... chromosome.
47. Enzyme complex involved in alcoholic fermentation is .....
48. The study of development of an organism from the egg to the adult stage is termed as .....
49. Nucleic acids were discovered by .....
50. The particles of basic blocks of the pigments containing membranes of the grana are called .....
51. When the anthers mature before stigma, the condition is termed as .....
52. *Nepenthes* usually grows in ..... deficient soil.
53. Fungi having no cross walls in their hyphae are termed as .....
54. Auxin brings about the positive gravitropism of ..... and the negative gravitropism of .....
55. Fusion of protoplast along with its nucleus is termed as .....
56. Those plants which grow and live on ..... and ..... organic matter of animals and plants are referred to as saprophytic plants.
57. Crossing over of alleles between homologous chromosomes occurs during chiasmata formation in ..... of .....
58. A parenchymatous cell with developed intercellular spaces which forms a connected system throughout the entire plant is known as .....
59. Anaerobic respiration after glycolysis is called .....
60. Tropic movement occurring in response to contact stimulus is called ..... movement.

ANSWERS

1. Parabolic
2. Adiabatic
3. Perpendicular
4. h
5. Ba
6. Mho, Siemen
7. – 12 units
8. Newton's third law of motion
9. Magnitude, direction
10. $J = I\omega$
11. Angular momentum
12. $\frac{2T}{r}$
13. Equal
14. Graham's law of diffusion
15. Mechanical, electromagnetic
16. 25
17. Four
18. Zero
19. Directly
20. Activates
21. Neutral ferric chloride
22. Linear
23. Four different
24. High
25. White
26. Hexamminecobalt (III) chloride
27. $Fe_2O_3 \cdot xH_2O$
28. Amalgams
29. Negative
30. Raoult's
31. Alleles, individuals
32. Founder
33. Genetic drift
34. Genes
35. Homozygous
36. Mutations
37. Recessive alleles
38. Males, females
39. Prophage
40. Conjugation
41. Transcribed
42. Reverse transcriptase, retroviruses
43. Hydrogen atoms, electrons, NAD^+
44. Structural, regulatory
45. Episomes
46. Polytene (salivary gland)
47. Zymase
48. Embryology
49. Miescher
50. Quantasomes
51. Protandry
52. Nitrogen
53. Non-septate
54. Roots, stems
55. Plasmogamy
56. Dead, Decaying
57. Prophase-I, Meiosis
58. Aerenchyma
59. Fermentation
60. Thigmotropic

HINTS

3. $\phi = \vec{B}\,\hat{n}\,ds$ where $\hat{n}$ is the unit vector normal to the area. When the area is held normally to the direction of flux density then

$$\vec{B}\,\hat{n} = B$$

$$\therefore \quad \phi = Bds.$$

7. $x = 2t^3 - 6t^2 + 12t + 6$

$$\frac{dx}{dt} = 6t^2 - 12t + 12$$

$$\frac{d^2x}{dt^2} = 12t - 12$$

$$\left(\frac{d^2x}{dt^2}\right)_{t=0} = -12$$

9. $(v_2 - v_1) = -(u_2 - u_1)$
16. $\because$ Molecular weight = 2 × V.D.
Gas is diatomic, hence atomic weight = 25.

●●●

ASSERTION AND REASON TYPE QUESTIONS

In each of the following questions, a statement of assertion (A) is given and a corresponding statement of reason (R) is given just below it. Of the statements, mark the correct answer as—

(A) If both A and R are true and R is the correct explanation of A

(B) If both A and R are true but R is not the correct explanation of A

(C) If A is true but R is false

(D) If both A and R are false

(E) If A is false but R is true

PHYSICS

1. **Assertion (A)** : When one mole of an ideal gas expands under adiabatic conditions so that it changes from (P_1, V_1, T_1) to (P_2, V_2, T_2), the work done by the gas is given by

$$\Delta W = C_v (T_1 - T_2)$$

Reason (R) : During adiabatic expansion $\Delta Q = 0$ and

$\Delta U = C_v (T_2 - T_1)$ in the expression

$$\Delta Q = \Delta U + \Delta W$$

(A) (B) (C) (D) (E)

2. **Assertion (A)** : Sound waves can not propagate through vacuum but light waves can.

Reason (R) : Sound waves can not be polarised but light waves can be.

(A) (B) (C) (D) (E)

3. **Assertion (A)** : When a body is projected at an angle 45°, its range is maximum.

Reason (R) : For maximum range the value of sin 2θ should be equal to one.

(A) (B) (C) (D) (E)

4. **Assertion (A)** : If a convex lens is kept in water its convergent power decreases.

Reason (R) : Focal length of convex lens in water increases.

(A) (B) (C) (D) (E)

5. **Assertion (A)** : 'Light year' is a measure of time.

Reason (R) : It has dimension of time.

(A) (B) (C) (D) (E)

6. **Assertion (A)** : Suppose a tunnel, which does not necessarily pass through the centre of the earth, connects two cities. If a coin is dropped in it, it will perform S.H.M. with a time period of $T = 2\pi \sqrt{R_e/g}$, where R_e is the radius of the earth.

Reason (R) : The restoring force acting on the coin is proportional to the displacement and acts opposite to it.

(A) (B) (C) (D) (E)

7. **Assertion (A)** : Two persons A and B each carrying a source of sound of frequency 400 Hz are standing a few metres apart. When A moves towards B, both persons hear the same number of beat per second.

Reason (R) : Doppler shift in frequency of sound is same whether the observer approaches the source or the source approaches the observer with the same speed.

(A) (B) (C) (D) (E)

8. **Assertion (A)** : Intensity of transmitted sound wave is always less than the intensity of the incident wave, but its amplitude may be greater.

Reason (R) : Intensity also depends on the density of the medium and the wave velocity in it. If these are small for the second medium, the amplitude can be greater.

(A) (B) (C) (D) (E)

9. **Assertion (A)** : Car headlights use parabolic reflectors.

Reason (R) : This geometry gives a very broad spread of light in the forward direction.

(A) (B) (C) (D) (E)

10. **Assertion (A)** : In resonance column, the closed end is a pressure antinode.

Reason (R) : A compression is reflected as a compression and a rarefaction is reflected as a rarefaction from a denser medium.

(A) (B) (C) (D) (E)

CHEMISTRY

11. **Assertion (A) :** Cooks know that the food has to be heated at a bit longer in the Salt Lake city to achieve same effect as in New York at sea level.

Reason (R) : When you live at higher altitudes, where the barometric pressure is less than 1 atm, water will boil at lower temperature.

(A) (B) (C) (D) (E)

12. **Assertion** : The compound, CCl_3F is widely used as a fluid in air conditioners and refrigerators.

Reason (R) : The compound CCl_3F has critical temperature of 198°C and critical pressure of 43·5 atm. It means CCl_3F vapour can be converted to liquid by applying modest pressure at any temperature below 198°C.

(A) (B) (C) (D) (E)

13. **Assertion (A)** : Food companies are using supercritical carbon dioxide (CO_2) to extract flavouring or odour causing compounds from natural food materials.

Reason (R) : The supercritical carbon dioxide dissolve polar compounds such as sugar, but it does not dissolve non-polar substances.

(A) (B) (C) (D) (E)

14. **Assertion (A)** : It is the surface tension that causes water drops

to be spheres and not the little cubes.

Reason (R) : The sphere has a smaller surface area than any other shape of the same volume.

(A) (B) (C) (D) (E)

15. **Assertion (A)** : Mercury does not climb the walls of a glass capillary and when it is placed in a tube it will have convex or upward-curving miniscus.

Reason (R) : For a liquid like mercury cohesive force *i.e.*, the surface tension is much greater than the adhesive forces towards glass.

(A) (B) (C) (D) (E)

16. **Assertion (A)** : The process of condensation is always exothermic in nature.

Reason (R) : The heat released during the condensation is equal in magnitude but opposite in sign to the enthalpy of vaporization.

(A) (B) (C) (D) (E)

17. **Assertion (A)** : The energy of hydration of Na^+ is somewhat larger than that of Cs^+ while that of Mg^{2+} is much larger.

Reason (R) : The distances between the ions and the water molecule are in the order.

$$Mg^{2+} > Na^+ > Cs^+$$

(A) (B) (C) (D) (E)

18. **Assertion (A)** : To explore the floor of the oceans, scientists, have built diving ships to operate at great depth. These ships are filled with an atmosphere of oxygen and helium at high pressure.

Reason (R) : Nitrogen of normal air is replaced by helium as nitrogen becomes more soluble in blood at high pressure and leads to nitrogen narcosis.

(A) (B) (C) (D) (E)

19. **Assertion (A)** : If we have one mole of hydrogen atoms, the ideal gas law tells, that the gas should occupy a volume of 22·4 litre at S.T.P.

Reason (R) : One mole of hydrogen atoms contain $6{\cdot}02 \times 10^{23}$ molecules of hydrogen.

(A) (B) (C) (D) (E)

20. **Assertion (A)** : In most of the reactions hydrogen peroxide acts as a strong oxidising agent.

Reason (R) : With stronger oxidising agents, hydrogen peroxide is oxidised and oxygen is evolved.

(A) (B) (C) (D) (E)

ZOOLOGY

21. **Assertion (A)** : Synaptic vesicles fuse with membrane and release neurotransmitter molecules.

Reason (R) : Attachment of neurotransmitter to receptor opens Na^+ channels and Na^+ flows into post synaptic cell causing depolarization.

(A) (B) (C) (D) (E)

22. **Assertion (A)** : Pain receptors are scattered throughout the skin and internal tissues.

Reason (R) : Stretch receptors wrap around specialized muscle cells and inform us of skeletal muscle stretching and tension.

(A) (B) (C) (D) (E)

23. **Assertion (A)** : Sebaceous glands release their product into a hair follicle through a short duct and cause hair lubrication.

Reason (R) : The product of the gland is an oily material called sebum which lubricates hairs, and preventing brittleness.

(A) (B) (C) (D) (E)

24. **Assertion (A)** : Homeostasis is the maintenance of a stable internal environment.

Reason (R) : This involves the coordinating activity of different cells, tissues, and organ systems.

(A) (B) (C) (D) (E)

25. **Assertion (A)** : Acetylcholine permits a nerve cell to communicate chemically with a muscle cell at a site called the neuromuscular junction.

Reason (R) : Upon its release, acetylcholine diffuses across the junction and binds to specific receptors on the plasma membrane of the muscle cell.

(A) (B) (C) (D) (E)

26. **Assertion (A)** : During fat catabolism, fatty acids and glycerol are processed by the Krebs cycle and the electron transport system generates energy.

Reason (R) : Energy is released from the electrons as they pass along a series of chemical reactions.

(A) (B) (C) (D) (E)

27. **Assertion (A)** : The regulation of RBC production is accomplished by the hormone follicle stimulating hormone.

Reason (R) : This hormone circulates to the red bone marrow, where it increase stem cell mitosis and speed the development of RBCs.

(A) (B) (C) (D) (E)

28. **Assertion (A)** : Erythroblastosis foetalis is a disease connected with Rh-factor and causes foetal death in the womb or soon after birth.

Reason (R) : Erythroblastosis foetalis results in massive destruction of foetal red blood cells, leading to foetal anaemia and severe tissue damage.

(A) (B) (C) (D) (E)

29. **Assertion (A)** : Prostaglandins are hormone like molecules produced by many body cells in mammals.

Reason (R) : Prostaglandins promote contractions of smooth muscles, platelet aggregation, inflammation and secretion.

(A) (B) (C) (D) (E)

30. **Assertion (A)** : Phagocyte cells digest microbes and debris.

Reason (R) : Natural Killer cells destroy virus-infected cells and turner cells.

(A) (B) (C) (D) (E)

BOTANY

31. **Assertion (A)** : Xenogamy is defined as the pollen grain transferred to stigma of same flower.

Reason (R) : In Xenogamy, the pollen grains of a flower transferred to stigma of a different flower of a different plant of different species.

(A) (B) (C) (D) (E)

32. **Assertion (A)** : Aerenchyma is characteristics of lithophyte.

Reason (R) : It is specialized tissue in vascular bundle among lithophytes.

(A) (B) (C) (D) (E)

33. **Assertion (A)** : Kornberg and Ochoa were awarded Nobel Prize.

Reason (R) : Because they provided mutation theory.

(A) (B) (C) (D) (E)

34. **Assertion (A)** : *Neottia* is saprophytic angiosperm.

Reason (R) : An association between a higher plant and a fungus is represented by mycorrhiza.

(A) (B) (C) (D) (E)

35. **Assertion (A)** : Resin canals are found in *Pinus*.

Reason (R) : These canals, present in cortex, are bounded externally by a layer of resin secreting glandular epithelial layer.

(A) (B) (C) (D) (E)

36. **Assertion (A)** : There is maximum occurrence of genetic diversity of crop plants where agriculture is primitive.

Reason (R) : In such primitive type maximum fauna and flora will survive without the undesirable interference of human being.

(A) (B) (C) (D) (E)

37. **Assertion (A)** : Vectors carry only the foreign gene into the host cell.

Reason (R) : Plasmids can carry recombinant DNA but viruses can not.

(A) (B) (C) (D) (E)

38. **Assertion (A)** : The prothallus of fern is mostly club-shaped.

Reason (R) : Development of prothallus occurs from the club-shaped zoosporangia.

(A) (B) (C) (D) (E)

39. **Assertion (A)** : In *Selaginella*, reduction division occurs in megaspores only.

Reason (R) : In *Selaginella*, reduction division occurs during formation of both microspores and megaspores.

(A) (B) (C) (D) (E)

40. **Assertion (A)** : 'Copy choice theory' of crossing over was proposed by J. Belling.

Reason (R) : This theory explains that the paired chromosomes in first meiotic phase duplicate their genes before the fibres that join them in tandem are developed.

(A) (B) (C) (D) (E)

ANSWERS WITH HINTS

1. (A) 2. (B) 3. (A) 4. (A) 5. (D)
6. (A) 7. (D) 8. (A) 9. (C) 10. (A)
11. (A) 12. (A) 13. (C) 14. (B) 15. (A)
16. (B) 17. (C) 18. (A) 19. (D) 20. (B)
21. (B) 22. (B) 23. (A) 24. (B) 25. (A)
26. (A) 27. (D) 28. (A) 29. (B) 30. (B)
31. (D) 32. (D) 33. (C) 34. (B) 35. (A)
36. (A) 37. (D) 38. (D) 39. (E) 40. (B)

1. The first law of thermodynamics is

$$\Delta Q = \Delta U + \Delta W$$

In adiabatic expansion $\Delta Q = 0$

$$\therefore \quad \Delta W = -\Delta U$$
$$= -C_v(T_2 - T_1)$$
$$= C_v(T_1 - T_2)$$

2. Sound waves are mechanical waves. For their propagation a material medium is essential. Hence they can not propagate through vacuum. On the other hand light waves are electromagnetic waves and do not need a material medium for their propagation. Hence they can propagate through vacuum.

Polarisation is the characteristics of transverse waves only. Sound waves being longitudinal can not be polarised. Light waves are transverse waves. Hence they can be polarised.

3. The expression for horizontal range of a projectile is

$$R = \frac{u^2 \sin 2\theta}{g}$$

clearly R is maximum when sin 2θ is maximum *i.e.*, sin 2θ = 1 or 2θ = 90°. Hence θ = 45°. Also

$$R_{max} = \frac{u^2}{g}$$

4. $$\frac{1}{f_a} = ({}_a\mu_g - 1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$
$$= \left(\frac{3}{2} - 1\right)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$
$$= \frac{1}{2}k \text{ where } k \text{ is constant.}$$

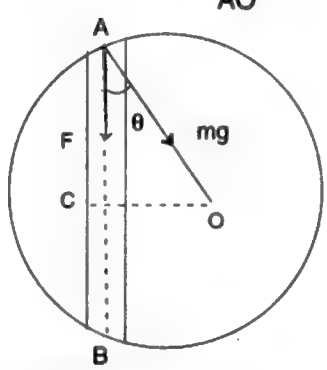
Similarly,

$$\frac{1}{f_w} = ({}_w\mu_g - 1)k$$
$$= \left(\frac{3/2}{4/3} - 1\right)k$$
$$= \frac{1}{8}k$$
$$\therefore f_w = 4f_a$$

The increase in focal length results in proportionate decrease in power as $P = \frac{1}{f}$.

5. A 'light year' is equal to the distance which light travels in vacuum in one year. Thus it measures distance. It has dimension of length and not of time. Thus both statements are wrong.

6. $$F = -mg\cos\theta$$
$$= -mg\frac{AC}{AO}$$



Acceleration

$$= -g\frac{AC}{R_e}$$

where AC is displacement of the ball. Hence,

Acceleration = $-\omega^2 \times$ Displacement

where $\omega^2 = g/R_e$

Hence the coin executes S.H.M. of time period.

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{R_e}{g}}$$

7. **Observer approaching the source**

In this case

Observer → v_0 Sound ← v Source • $v_s = 0$

$$n' = \frac{v + v_0}{v_s} \times n$$

Source approaching the observer

In this case

Observer ← Sound ← Source

$v_0 = 0$ v v_s

$$n'' = \frac{v}{v - v_s} \times n$$

Clearly $(n' - n)$ is not the same as $(n'' - n)$.

In view of this both statements (assertion and reason) are wrong.

8. If a simple harmonic progressive wave is travelling with velocity v in a medium of density ρ, its intensity is given by,

$$I = 2\pi^2 n^2 a^2 \rho v$$

where a is amplitude and n is the frequency of the wave.

In case of transmitted wave intensity is always less than the intensity of the incident wave due to absorption of energy in the medium. As intensity also depends on ρ and v, a may be larger in the second medium if ρ and v are smaller in it.

9. Car head lights use parabolic reflectors. The reason is that when the source is placed at or near its focus, we get a long distance parallel beam of light (and not a very broad beam of light).

10. In resonance column water surface acts as closed end. A node is always formed here. At the node variation of pressure and density is maximum. Hence it acts as antinode (maximum variation) of pressure. The given reason explains this variation of pressure at a node.

27. The regulation of RBC production is accomplished by the hormone erythropoietin which is secreted by the kidney. This hormone circulated to the red bone marrow, where it increases stem cell mitosis and speeds the development of red blood cells.

31. In xenogamy condition, pollen grains of a flower transferred to a stigma of a different flower on a different plant of the same species.

32. Aerenchyma is a specialized tissue found in certain hydrophytes, characterized by thin-walled cells and large intercellular spaces.

33. **Ochoa** and **Kornberg** were awarded Nobel Prize for artificial synthesis of DNA and RNA.

37. Both viruses and plasmids can serve as vectors.

38. The prothallus of fern is heart-shaped. ●●●

(Continued from Page 111)

OBJECTIVE QUESTIONS

1. Which of the following theories explains that protoplasm is a collection of minute droplets of a liquid distributed in another liquid as an emulsion ?
   (A) Reticular theory
   (B) Granular theory
   (C) Fibrillar theory
   (D) Alveolar theory

2. The most important physical character of protoplasm, as known today, is that it is a/an—
   (A) Complex colloidal system
   (B) Emulsion system without protein
   (C) Inorganic compound
   (D) Organic compound

3. Which of the following inorganic and organic compounds is present in larger percentage in protoplasm ?
   (A) Oxygen and carbondioxide gases
   (B) True lipids
   (C) Water
   (D) Inorganic salts

4. The protoplasm which is filled in the nucleus is called—
   (A) Cytoplasm
   (B) Nucleoplasm
   (C) Nucleosome
   (D) All of the above

5. The protoplasm which exists between the nucleus and the plasma membrane is called—
   (A) Nucleoplasm
   (B) Spherosome
   (C) Nucleosome
   (D) Cytoplasm

6. The physical basis of life is—
   (A) Endoplasm
   (B) Protoplasm
   (C) Nucleoplasm
   (D) Ectoplasm

7. Which of the following are linked together in long chains to form proteins ?
   (A) Pyrimidines
   (B) Purines
   (C) Amino acids
   (D) Sugars

8. The term protoplasm was first given by—
   (A) Watson (B) Nirenberg
   (C) Hertwig (D) Purkinje

9. Among the following elements in protoplasm, the highest percentage is of—
   (A) Oxygen (B) Carbon
   (C) Nitrogen (D) Hydrogen

10. Who among the following described protoplasm as 'a system in dynamic equilibrium' ?
   (A) Thomson (B) Sharp
   (C) Altman (D) Purkinje

ANSWERS

1. (D) 2. (A) 3. (C) 4. (B) 5. (D)
6. (B) 7. (C) 8. (D) 9. (A) 10. (B)

●●●

(Continued from Page 114)

46. The transition reaction is so called because it connects glycolysis to the krebs cycle. In this reaction pyruvate is converted in to a two-carbon **acetyl group** attached to *coenzyme*-A, and CO_2 is given off. This is an oxidation reaction in which hydrogen atoms ($e^- + H^+$) are removed from pyruvate by *dehydrogenase* that uses NAD^+.

49. The initial (first) community to inhabit an area is referred to as pioneer community.

50. Seres on primary area are known as **priseres** and on secondary areas as **subseres**. The sequence of developmental stages from pioneers to the climax community is known is **sere**.

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Do You Know?

Q. What is neurotransmitter ?

☞ Neurotransmitter is a chemical that helps brain cells, neurons, communicate with one another. These chemical messengers act on highly specific receptor protein molecules. Any interference, with transmitters of the receptor proteins, causes changes in the way the brain functions. Drugs of abuse, *i.e.*, nicotine, ecstasy, morphine or heroin, alter the way in which natural transmitter-receptor transaction takes place, resulting in drastic changes in human behaviour. By modifying how these transmitters are made in brain, their abundance, and their targets, therapeutic drugs can also be made to combat a range of mental disorders.Neurotransmitters are mostly found on the junctions between nerve cells and muscles. There are about 50 different neurotransmitters, the most common being acetylcholine and norepinephrine. Acetylcholine is important in cognitive and learning processes.

Q. What is second messenger ?

☞ Second messengers are organic molecules and sometimes metal ions, acting as intracellular signals, whose production or release usually amplifies a signal such as a hormone, received at the cell surface. Some hormones bind to the cell membrane and activate an enzyme there to generate the second messenger. Alternatively, the ligand may be a non-hormone which opens or closes a Gated Channel affecting membrane permeability to an ion Calcium ion (Ca^{++}) concentration is extremely important in control of many cell functions. First organic molecule hailed as a second messenger was cyclic AMP, but others have also been discovered, such as Inositol 1, 4, 5-Triphosphate ($InsP_3$).

Q. What is the history of discovery of aspirin ?

☞ In 1763, the reverend Edmund Stone took the first step towards the discovery of one of the most commonly used medicines when he noted that the bark of the English Willow was an effective treatment for patient suffering from fever.

It took 50 years before the active ingredient of Willow bark was isolated and named **salicin**, from the latin name for the Willow (salix alba). Another 50 years elapsed before a large-scale synthesis of this compound was available. By that time the compound was known as **salicylic acid.** Many patients treated with this drug complained of chronic stomach irritation because of high acidity. **Felix Hoffman** searched the chemical literature for a less acidic derivative of salicylic acid. In 1898, Hoffman reported that the acetyl ester of salicylic acid was more effective and easier to tolerate than the parent compound. He named this compound **aspirin** taking prefix a-from the name of **acetyl group** and spirin from the German name of the parent compound **spirsaure.**

Q. What is Industrial Melanism ?

☞ Industrial melanism is a common occurrence in insects of high frequency of dark (melanic) forms of species in regions with high industrial pollution, where surfaces on which to rest are darkened by soot and where atmospheric SO_2 levels are high enough to prevent crustose lichen growth. A mutation darkening an individual will tend to be selected for in polluted regions since it will decrease the bearer's risk of falling prey to a visual predator; but in non-polluted parts of the species range the non-melanic form will be advantageous and occur with higher frequency.

Before the Industrial Revolution in England, peppered moth (*Biston betularia*) were light coloured. Several decades after the Industrial Revolution, however, black moths made up of 99% of the moth population in air-polluted areas. This provides evidence in support of the theory that dominance is an evolving property of characters in populations of species. Thus industrial melanism provides one of the best examples of evolution within species and of selection resulting in polymorphism.

Q. How many amino acids are converted into α-ketoglutarate ?

☞ Five amino acids are converted into α-ketoglutarate. The carbon skeletons of five amino acids (proline, glutamine, histidine, arginine and glutamine) enter citric acid cycle via α-ketoglutarate. The cyclic structure of proline is opened by oxidation of the carbon most distant from the carboxyl group to create a **Schiff base** and hydrolysis of schiff base to a linear semialdehyde. This is further oxidized at the same carbon to produce glutamate. Transamination or deamination of glutamate produces the citric acid cycle intermediate α-ketoglutarate. The catabolic conversion of arginine and histidine to glutamate is slightly more complex than the path from proline or glutamine to glutamate.

Q. What is the chemistry of human hair ?

☞ Human hair contains proteins that are about 14% cysteine. Hair curls as it grows because of the disulphide (—S—S—) links between cystein residues on adjacent protein molecules. The first step in changing the ways hair curls involves shaping the hair to our satisfaction and then locking it into place with curlers. The hair is then treated with mild reducing agent that reduces the —S—S— bonds to pairs of —SH groups. This relaxes the structure of the protein in the hair, allowing them to pick up the structure dictated by the curlers. The —SH side chains on cystein residues, that are now adjacent to each other, are then oxidised by O_2 in the air. New —S—S— linkages form, locking the hair permanently in place.

Q. What are kidney stones ?

☞ Kidney stones, or renal calculi, formed from calcium oxalate, uric acid, and calcium phosphate. They are formed in the renal pelvis when these solutes become so concentrated that they form solids (stones). When these stones pass through the ureters or urethra, they may obstruct urine flow and their sharp points may cause pain and bleeding. The formation of kidney stones is more common in warm climates where sweating increases. Kidney reabsorption of water, producing a concentrated urine in the renal pelvis. Individuals confined to a bed or a wheelchair may suffer a higher frequency of kidney

stones because of the demine ralization of bone associated with reduced physical activity.

Q. What do you mean by Stem-succulent deserts ?

☞ These striking formations are of rather limited extent and consist of only the **Sonoran Desert** (Gran Desierto) of Arizona and Northwestern Mexico. Their special appearance rest on the geographical availability of certain plant groups absent from many of the deserts. For example, the cactus family (Cactaceae) and the arborescent members of family Euphorbiaceae mainly found. These plants have adopted a special growth habit that provides one alternative solution to the problem of survival in drought.

Q. What do you mean by association of protein subunits ?

☞ The subunits, which are called monomers or protomers, usually are present as an even number. Less than 10% of the polymers have been found to have an odd number of monomers. The arrangement of subunit is thought to be regular and may be cyclic, cubic or tetrahedral. Some of the small proteins also contain subunits. For example, **insuline**, with a molecular weight of 6000, consists of two peptide chains linked to each other by disulphide (—S—S—) bridges. In other proteins, hydrogen bonds and hydrophobic bonds cause the formation of aggregates of the subunits. The subunits of some proteins are identical; those of others differ.

Q. What is Chargaff's Rule ?

☞ Within each species, DNA has the constancy required of the genetic material. Further, the percentage of A(adenine) equals the percentage of T(thymine) and the percentage of G equals the percentage of C (cytosine). The percentage of A + G equals 50% and the percentage of T + C equals 50%. These relationships are called chargaff's rules. Thus, Chargaff's rules are as follows—

1. The amount of A.T.G. and C in DNA varies from species to species.

2. In each species, the amount of A = T and the amount of G = C. Chargaff's data suggest that A is always paired with T and G is always paired with C.

Q. What do you mean by filamentous water molds ?

☞ The water molds belong to phylum-oomycota live in the water, where they parasitize fishes. Most water molds are saprophytic and live off dead organic matter. Water molds have a filamentous body as do fungi; but their cell walls are largely composed of cellulose whereas fungi have cell walls of chitin. The life cycle of water molds differ from that of fungi. During asexual reproduction water molds produce motile spores (2*n* zoospores), which are flagellated. The adult is diploid (not haploid as in fungi), and meiosis produces the gametes. Their phylum name refers to the enlarged tips (called **oogonia**) where eggs are produced. A water mold was responsible for 1840s potato famine.

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(Continued from Page 117)

38. **Wolffia** is a free-floating hydrophyte.

40. Each of the small organic molecule can be a unit of a large organic molecule called macromolecule which in turn is known as **polymer.** Polymers are broken down by hydrolysis, which is essentially a reverse of condensation.

41. Sucrose is a disaccharide that contains glucose and fructose. Sugar is transported within the plant's body in the form of sucrose, and this the sugar we use at the table to sweeten our food.

42. The most common polysaccharides in living beings are starch, glycogen and cellulose. Each of these is a polymer of glucose.

44. The CO_2 is accepted by ribulose 1, 5-diphosphate (**RuBP**) already present in the cell and a 6-carbon addition compound is formed which is unstable. It soon gets converted into 2 mol. of 3-PGA. Both these reactions occur in the presence of **carboxydismutase** enzyme.

45. **Steward** (1964) gave the concept of cellular totipotency. Cellular totipotency is the ability of a somatic cell to produce the complete organism. This property is present in meristem.

46. Tissue culture is a technique of maintaining and growing cells, tissues etc., and their differentiation on artificial medium under aseptic conditions inside suitable containers.

48. Genetically dwarf plants like pea (*Pisum sativum*) and maize (*zea mays*) show normal size in the presence of gibberellins due to stimulation of internodal growth.

50. Genes are segments of nucleic acid and not the complete ones. Genes of tobacco mosaic virus (**TMV**) are, therefore, polyribonucleotides but not the complete RNA.

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(Continued from Page 118)

autosomal trisomy seen among humans is trisomy 21 (Down's syndrome), which occurs in one out of several hundred live births.

10. The soil which develops *in situ* above parent bedrock is known as **Sedentary** or **residual soil.**

14. The petiole may continue into the midrib which bears branches and sub-branches ultimately ramifying in the leaf lamina in both reticulate and parallel type of venation. The ultimate branches are very small and terminate in bundle ends. Often these ends bend into minute specialized photosynthetic areas known as **vein islets.**

●●●

GENERAL KNOWLEDGE

1. Who was the political guru of Subhash Chandra Bose ?
   (A) Rabindra Nath Tagore
   (B) Aurbindo
   (C) C. R. Das
   (D) B. G. Tilak
2. 'Prince of Wales Cup' is related with—
   (A) Golf (B) Hockey
   (C) Foot ball (D) Cricket
3. The first speaker of Lok Sabha was—
   (A) Sardar Hukum Singh
   (B) G. V. Mavalankar
   (C) A. S. Aiynger
   (D) Nilam Sanjiva Reddy
4. The place which experiences minimum temperature in winter is—
   (A) Srinagar (B) Leh
   (C) Shimla (D) Manali
5. The capital of Lakshadweep is—
   (A) Port Blair (B) Silvasa
   (C) Kavarati (D) Kohima
6. 'Kozhikode' is the new name of—
   (A) Cochin
   (B) Calicut
   (C) Quilon
   (D) None of these
7. 'Panchayat' is the parliament of—
   (A) Bangladesh
   (B) Iran
   (C) Nepal
   (D) Spain
8. Which of the official document is related with India ?
   (A) White paper
   (B) Blue book
   (C) Green paper
   (D) Yellow book
9. The supreme commander of India's defence is—
   (A) Chief of the army
   (B) Prime Minister of India
   (C) President of India
   (D) Defence Minister
10. Diabetes can be controlled by the injection of—
    (A) Thyroxion
    (B) Tetracyclin
    (C) Streptomycin
    (D) Insulin
11. Sanchi-Stupa is situated in which of the following states ?
    (A) Bihar
    (B) Andhra Pradesh
    (C) Madhya Pradesh
    (D) Maharashtra
12. Who among the following can be removed from the office without impeachment ?
    (A) President of India
    (B) Chief Justice of India
    (C) Governor of a state
    (D) Chief Election Commissioner
13. Which of the following rivers flows from east to west to join the Arabian sea ?
    (A) Mahanadi (B) Krishna
    (C) Narmada (D) Cauvery
14. 'Anand Math' was written by—
    (A) Rabindra Nath Tagore
    (B) Bankim Chandra Chatterjee
    (C) Raja Ram Mohan Roy
    (D) None of these
15. Which of the following states does not have common boundary with Bangladesh ?
    (A) Assam (B) Meghalaya
    (C) Nagaland (D) Tripura
16. James Bond is a character created by —
    (A) Johnson
    (B) Wordsworth
    (C) Ian Fleming
    (D) Shakespeare
17. E-mail is—
    (A) Electronic mailing
    (B) Computer software
    (C) Local area network
    (D) Wide area network
18. The salutation of 'Jai Hind' was given by—
    (A) Jawahar Lal Nehru
    (B) Mahatma Gandhi
    (C) Subhash Chandra Bose
    (D) Bal Gangadhar Tilak
19. 'Chittaranjan' is famous for which of the following industries ?
    (A) Oil refinery
    (B) Coal mines
    (C) Locomotives
    (D) Aluminium
20. The 'Gate way of India' is situated in—
    (A) Delhi (B) Mumbai
    (C) Calcutta (D) Chennai
21. Vitamin 'A' is necessary in our body for—
    (A) Prevention of blood clotting
    (B) Haemoglobin synthesis
    (C) Proper vision
    (D) Proper digestion
22. Myopia is a defect of vision of not clearly seeing—
    (A) Near objects
    (B) Distant objects
    (C) Coloured objects
    (D) Small objects
23. Which of the following is an anti-tank missile developed in India ?
    (A) Agni (B) Trishul
    (C) Nag (D) Akash
24. 'Lakshadweep' is situated in—
    (A) Arabian sea
    (B) Bay of Bengal
    (C) Indian ocean
    (D) None of these
25. Which article of the Constitution of India empowers the Parliament to amend the constitution ?
    (A) 370 (B) 358
    (C) 368 (D) 356
26. How many languages are recognised by the Constitution of India in the 8th schedule ?
    (A) 15 (B) 18
    (C) 14 (D) 16
27. 'National Defence Academy' is situated at—
    (A) Dehradun (B) Khadagvasla
    (C) Delhi (D) Chennai
28. 'Central Building Research Institute' is located at—
    (A) Lucknow (B) Roorkee
    (C) Varanasi (D) Pune

29. Hirakud dam is constructed on—
(A) Sutlej (B) Tungbhadra
(C) Chambal (D) Mahanadi

30. Which of the following trains has the longest route length ?
(A) Himsagar Express
(B) Himgiri Express
(C) G. T. Express
(D) Guwahati—Trivendrum Express

31. 'Kadambari' was written by—
(A) Kalidas
(B) Banbhat
(C) Kalhan
(D) Jai Shankar Prasad

32. 'Jalianwala Bagh tragedy' occurred in—
(A) 1911 (B) 1919
(C) 1924 (D) 1929

33. 'Mahakaleshwar temple' is situated at—
(A) Ayodhya (B) Mathura
(C) Madurai (D) Ujjain

34. 'Kuchipudi' dance is associated with—
(A) Kerala
(B) Madhya Pradesh
(C) Andhra Pradesh
(D) W. Bengal

35. 'Kanha National Park' is situated in—
(A) Uttar Pradesh
(B) Andhra Pradesh
(C) Madhya Pradesh
(D) Himachal Pradesh

36. 'Abyssinia' was the old name of—
(A) Ethiopia
(B) Taiwan
(C) Myanmar
(D) None of these

37. The currency of spain is—
(A) Peseta (B) Lira
(C) Rial (D) Rouble

38. Which of the following is used for artificial rain ?
(A) Silver Bromide
(B) Ammonium Nitrate
(C) Silver Iodide
(D) All of these

39. Nisha Mohota is associated with—
(A) Cricket (B) Badminton
(C) Chess (D) Swimming

40. Who has written the book 'Fasting and Feasting' ?
(A) Salman Rushdie
(B) Anita Desai
(C) Khushwant Singh
(D) None of these

ANSWERS

1. (C) 2. (A) 3. (B) 4. (B) 5. (C)
6. (B) 7. (C) 8. (A) 9. (C) 10. (D)
11. (C) 12. (C) 13. (C) 14. (B) 15. (C)
16. (C) 17. (A) 18. (C) 19. (C) 20. (B)
21. (C) 22. (B) 23. (C) 24. (A) 25. (C)
26. (B) 27. (B) 28. (B) 29. (D) 30. (A)
31. (B) 32. (B) 33. (D) 34. (C) 35. (C)
36. (A) 37. (A) 38. (C) 39. (C) 40. (B)

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CSV Crossword–18

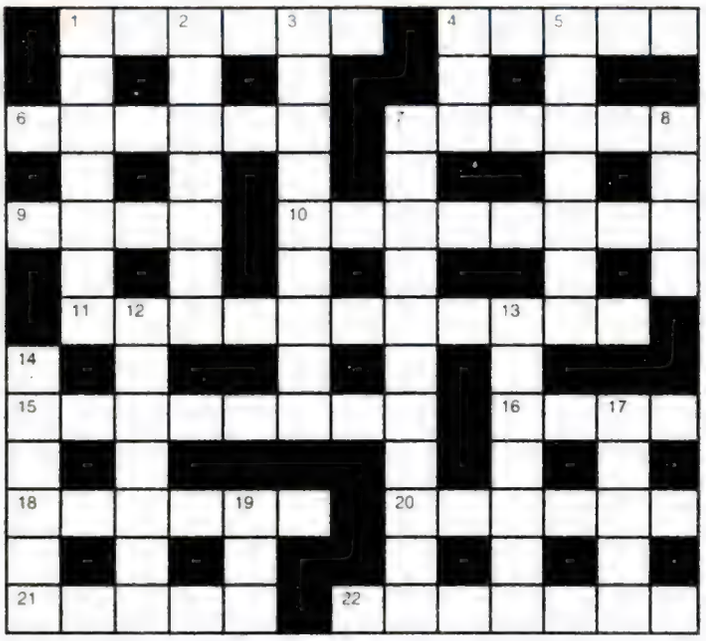
ANSWERS

Across : (1) BARN (3) PARTICLE (9) CADMIUM (10) TUNED (11) NORTH (12) TUNNEL (14) EMPTY ORBITALS (17) FRENCH (19) EIGHT (22) LOGIC (23) NOT GATE.

Down : (1) BICONVEX (2) RADAR (4) AMMETER SHUNTS (5) TITAN (6) CANDELA (7) EDDY (8) EIGHTY (13) ISOTHERM (15) PERIGEE (16) INERTIA (18) NICHE (20) GRAIN (21) SLIP.

1 B	A	2 R	N	■	3 P	4 A	R	5 T	I	6 C	L	7 E
I	■	A	■	8 E	■	M	■	I	■	A	■	D
9 C	A	D	M	I	U	M	■	10 T	U	N	E	D
O	■	A	■	G	■	E	■	A	■	D	■	Y
11 N	O	R	T	H	■	12 T	U	N	N	E	L	■
V	■	■	■	T	■	E	■	■	■	L	■	13 I
14 E	M	15 P	T	Y	O	R	B	16 I	T	A	L	S
X	■	E	■	■	■	S	■	N	■	■	■	O
■	17 F	R	E	18 N	C	H	■	19 E	I	20 G	H	T
21 S	■	I	■	I	■	U	■	R	■	R	■	H
22 L	O	G	I	C	■	23 N	O	T	G	A	T	E
I	■	E	■	H	■	T	■	I	■	I	■	R
24 P	R	E	C	E	S	S	■	25 A	L	N	■	M

CSV Crossword–19



Across :

1. The name of a satellite of Mars (6).
4. A very famous mathematician of incredible talent (5).
6. Self evident truths, used as basis for the development of a theory (6).
7. The e-neutrino, the electron, the muon; all are essentially a ..... (6).
9. The resistor colour code for number 8 (4).
10. The symmetry of ..... of space has as a consequence, the law of conservation of angular momentum [The property that the laws of physics are invariant under .....] (8).
11. The impulsive feeling of challenge you get when you encounter some tough problems, and you say to yourself : .... (3, 2, 2, 4).
15. The perfume spray working on Bernoulli's theorem is also known as an ..... (8).
16. Not a common element, but ..... (4).
18. Pertaining to the eye (6).
20. A line is a collection of infinite ..... (6).
21. Magnitude of velocity is ..... (5).
22. Heavier than the proton (7).

Down :

1. Pertaining to the Right side (7).
2. Line on a map joining points of equal rainfall (7).
3. Experimentalists are essentially ..... of physical phenomena (9).
4. Optical instrument, the oldest and natural (3).
5. The 3-*d* pattern of atomic sites in a crystal is known as a ..... (7).
7. The art of painting figures on stone surfaces (11).
8. The decimal equivalent of binary 1001 (4).
12. For a curve, the locus of the centres of curvatures of different points (7).
13. A famous mathematical analyst (7).
14. When eyes are not dry, we see ..... around point sources of light (6).
17. You take a ..... when you divide two numbers (5).
19. To get the resultant velocity, you ..... the velocity vectors (3).

Note—Its solution will be published in the next issue.

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(Continued from Page 124)

22. Hydrogen bonding in propionic acid is stronger than that in butanol.
23. Schotten-Baumann reaction

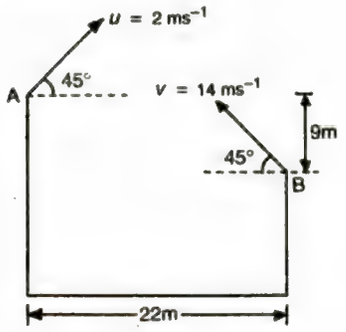
$$\underset{\text{Phenol}}{C_6H_5OH} + \underset{\text{Benzoyl chloride}}{ClCOC_6H_5} \xrightarrow{\text{aq. NaOH}} \underset{\text{Phenyl benzoate}}{C_6H_5OCOC_6H_5} + HCl$$

24. Addition of $(NH_4)_2SO_4$ will precipitate out group V radicals (Ba^{2+}, Ca^{2+}, Sr^{2+}) as sulphates along with group III radicals.
27. Molecularity of a reaction can never be zero.
34. Genotoxicity refers to the detection of agents that damages DNA and hence, cause mutations.
36. Cancerous tumours arising from epithelial tissues are called carcinomas.
38. Synthesis of pyruvic acid, glucose or glycogen from amino acids is called gluconeogenesis.
40. The cavity of medulla oblongata is called fourth ventricle.
41. The ampullae of lorenzini is a thermoreceptor organ.
42. Galactosemia is the inability to convert galactose to glucose.
45. Transmission of the nerve impulse across a synapse is accomplished by the movement of Ca^{++}. As an impulse arrives at a synaptic knob, calcium ions (Ca^{++}) diffuse into the knobs from surrounding tissue fluid.
46. The skeleton of the plant shoot is formed by the **root**.
48. While the stem is growing, the lateral buds develop at every leaf axil in **acropetal succession**.
49. The genetic material must be able to store information, be replicated, and undergo mutations.
52. The genetic code is a triplet code, and each codon (code word) consists of three bases.
54. The proteinaceous part of the enzyme is called **apoenzymes.**
55. Indol acetic acid (IAA) is the most naturally occurring auxin.
57. Transposons are movable genetic elements similar to jumping genes reported in bacteria.
59. The enzyme responsible for the reduction of molecular nitrogen to the level of ammonia in the leguminous root nodule.

●●●

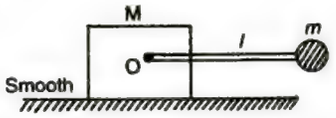
C S V QUIZ CONTEST

1. Two particles are simultaneously thrown from roofs of two high buildings as shown in figure. Their velocities of projection are $2ms^{-1}$ and $14ms^{-1}$ respectively. Horizontal and vertical separation between points A and B is 22m and 9m respectively. The minimum separation between the particles in the process of their motion is—



(A) 3·0 m (B) 6·0 m
(C) 9·0 m (D) 12·0 m

2. A block of mass M is placed on a smooth horizontal floor. The block has a massless rod of length *l* pivoted in it at point O. The rod has a point mass *m* attached at its end. The whole system is released from the position shown. The velocity of M when the rod becomes vertical is—



(A) $M\sqrt{\frac{2gl}{m(M+m)}}$

(B) $M+m\sqrt{\frac{2gl}{m}}$

(C) $m\sqrt{\frac{2gl}{M(M+m)}}$

(D) $M+m\sqrt{\frac{2gl}{M-m}}$

3. A current of 2·0 A exists in a wire of cross sectional area 1·0 mm^2. If each cubic metre of the wire contains $6·0 \times 10^{28}$ free electrons, find the drift speed—
(A) $2·1 \times 10^{-3}$ m/s
(B) $1·2 \times 10^{-5}$ m/s
(C) $2·1 \times 10^{-4}$ m/s
(D) None of these

4. An electron moves in a circle of radius 10 cm with a constant speed of $4·0 \times 10^6$ ms^{-1}. Find the current at a point on the circle—
(A) $1·0 \times 10^{-11}$ μA
(B) 1·5 μμA
(C) $2·0 \times 10^{-12}$A
(D) $1·0 \times 10^{-12}$A

5. A proton, a deuteron and an α particle moving with equal kinetic energies enter perpendicularly into a magnetic field. If r_p, r_d and r_α are the respective radii of the circular paths,the ratios $\frac{r_p}{r_d}$ and $\frac{r_p}{r_\alpha}$ respectively are—
(A) $\frac{1}{\sqrt{2}}$ and 1
(B) 1 and $\frac{1}{\sqrt{2}}$
(C) $\frac{1}{2}$ and 1
(D) None of these

6. Which of the following species has lowest oxidation number for nitrogen ?
(A) NH_4^+ (B) NaN_3
(C) NH_2OH (D) N_2

7. Which is the incorrect statement ?
(A) N≡N triple bond is much weaker than P≡ P triple bond
(B) P–P single bond is stronger than N–N single bond
(C) Phosphorus is much less electronegative than nitrogen
(D) Phosphorus can expand its valence shell to hold more than eight electrons.

8. Which of the following pairs of ions cannot coexist in the aqueous solution ?
(A) Cr^{2+} and MnO_4^-
(B) Fe^{3+} and $Cr_2O_7^{2-}$
(C) Cr^{2+} and I^-
(D) Mn^{2+} and Cl^-

9. Which of the following metals is strongest reducing agent ?
(A) Cr (B) Mn
(C) Co (D) Ni

10. In which of the following process is ΔS° positive ?
(A) $2NO_{(g)} + Cl_{2(g)} \rightleftharpoons 2NOCl_{(g)}$
(B) $NaCl_{(s)} \rightleftharpoons NaCl_{(l)}$
(C) $3O_{2(g)} \rightleftharpoons 2O_{3(g)}$
(D) $C_2H_{4(g)} + H_{2(g)} \rightleftharpoons C_2H_{6(g)}$

11. When a substrate for an enzyme stimulates synthesis of that enzyme, it is called a gene—
(A) Repressor (B) Inducer
(C) Activator (D) Excitant

12. A polypeptide is assembled on a—
(A) DNA molecule
(B) Nuclear membrane
(C) Nuclear pore
(D) Ribosomes

13. The first true hominids in the fossil record have been placed in the genus—
(A) Australopithecus
(B) Homo
(C) Dryopithecus
(D) Aegyptopithecus

14. Which of the following helps an animal get rid of body heat ?
(A) Long ears
(B) Light-coloured hair or feathers
(C) Subcutaneous fat
(D) Large body

15. Which part of brain has greatest influence over the endocrine system ?
(A) Amygdala
(B) Cerebral cortex
(C) Hypothalamus
(D) Medulla oblongata

16. Which of the following byproducts of glycolysis is known as Newberg's ester ?
(A) Glucose-6-phosphate
(B) Fructose-6-phosphate
(C) Fructose 1, 6-diphosphate
(D) All of the above

17. Conidiospores are formed—
(A) By sac, club and imperfect fungi only
(B) During sexual reproduction

(C) By sporangia
(D) When nutrients are available in lesser amount

18. In which of the following phyllotaxy the ninth leaf is found above the first leaf and the genetic spiral completes three circles ?
(A) Distichous phyllotaxy
(B) Tristichous phyllotaxy
(C) Pentastichous phyllotaxy
(D) Octastichous phyllotaxy

19. CAM plants use *PEP carboxylase* to fix some CO_2 at / during—
(A) Light or day
(B) Night or dark
(C) Both A and B
(D) None of the above

20. Which of the following is broken down completely to CO_2 and water during aerobic respiration ?
(A) Pyruvate from glycolysis
(B) Malate from glycolysis
(C) Acetyl-Co-A from Krebs cycle
(D) None of the above

●●●

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1. All students or those appearing in competitive examinations can take part in this contest.
2. Candidates taking part in quiz contest will necessarily have to send their entries by a fixed date. Entries are to be sent by ordinary post. Please mark your envelope **'Quiz–Competition Science Vision'** on the top left hand side.
3. Answers given only on the form of the magazine will be admissible.
4. In the form there are four squares against each question number. Contestants should put a cross (×) in the square for the answer they think is correct. Giving more than one answer to a question will disqualify it.
5. Contestants should essentially write the number of questions they have solved.
6. Marks will be deducted for wrong answers.
7. The candidate sending the maximum number of correct answers will be given Rs. 400 as first prize. Next two candidates after that will get Rs. 300 and Rs. 200 as second and third prize respectively. If there are more than one candidate eligible for a prize, the amount will be equally distributed among them.
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Solution to Quiz No. 22

Competition Science Vision

Last date for sending 28th March, 2000

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I have read and understood the rules of quiz contest of Competition Science Vision issued by Pratiyogita Darpan and agree to abide by them.

.....

(Signature)

RESULT

No. of questions attempted.....

No. of correct answers.....

No. of wrong answers.....

Marks obtained.....

ANSWER FORM

Q. No.	A	B	C	D	Q. No.	A	B	C	D
1.	☐	☐	☐	☐	11.	☐	☐	☐	☐
2.	☐	☐	☐	☐	12.	☐	☐	☐	☐
3.	☐	☐	☐	☐	13.	☐	☐	☐	☐
4.	☐	☐	☐	☐	14.	☐	☐	☐	☐
5.	☐	☐	☐	☐	15.	☐	☐	☐	☐
6.	☐	☐	☐	☐	16.	☐	☐	☐	☐
7.	☐	☐	☐	☐	17.	☐	☐	☐	☐
8.	☐	☐	☐	☐	18.	☐	☐	☐	☐
9.	☐	☐	☐	☐	19.	☐	☐	☐	☐
10.	☐	☐	☐	☐	20.	☐	☐	☐	☐

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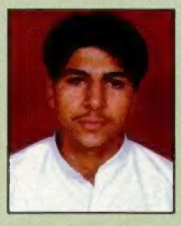

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